TOPICS OF THE MONTH

Heavy chemicals and cleaner air

'COMPLAINTS is many and various,' as it says in the poem, and the Chief Alkali Inspector for England and Wales, whose task it is to investigate complaints of air pollution and lead us to a brighter, cleaner world, has had his task complicated since June 1, 1958, the second 'appointed day' for the Clean Air Act, when the Alkali Act was extended to cover a further 11 classes of works. The latest report* points out that, as a result, the number of registered works increased from 872 at the end of 1957 to 2,160 at the end of 1958, and the number of separate processes at those works from 1,733 to 3,412.

Complaints were investigated at 270 works compared with 133 in 1957. Of the 207 complaints against registered works, 140 related to those which have become registerable since last June. Chief amongst the offenders were ceramic works (43), gas and coke works (36), electric power stations (27), iron and steel works (20), aluminium works (13) and cement works (13).

The report, as usual, provides an illuminating picture of the trend of production, particularly in the heavy chemical industry. It points, for instance, to the remarkable changes in the sulphuric acid industry in the last 20 years, 19% of total production being made by chamber and tower processes in 1958 compared with 39.7% in 1938. Production last year was 2,023,000 tons as monohydrate, compared with 2,137,000 in 1957 and 821,000 in 1938.

It is also noted that 15 works are registered in respect of the decomposition of common salt and, to a very much less extent, of muriate of potash. As against the 63,500 tons of salt used in the saltcake process in 1957, 56,200 tons of it were so used in 1958—two big works contributed 34,400 of this total. A new works has recently been started up in South Wales while four small works were idle for all or the greater part of 1958 and three are unlikely to work again. Of the two products, hydrochloric acid is made also by synthetic processes and there is also an appreciable production as by-product acid from the chlorination of organic compounds. Some sulphate of soda, the other product, is obtained by other routes.

Amongst complaints investigated were those laid at the door of fertiliser granulating plants, where waste gases from the process are passed through cyclones followed by water scrubbers. Properly operated, these should reduce the dust burden and the acidity to a very low figure, the average acidity figure for 1958 being 0.17 gr./cu.ft., calculated as sulphur trioxide. The trouble, which has developed over recent years, is due to the tendency for emissions to give a persistent mist. Pending a more fundamental study of the whole mist production and arrestment problem the Inspectorate have asked for chimneys of not less than 120 ft. in height wherever there is complaint.

A pat on the back is given to the large works producing chlorine, and using large quantities of chlorine in various syntheses, for their high standards of maintenance and operation. However, a serious emission of chlorine did occur at one plant, engaged in an organic synthesis, where two gases, one of them chlorine, are reacted. Emission was caused by the blowing of a seal consequent on the build-up of abnormal pressure of chlorine due to temporary failure in the feed of the other gaseous reactant. To minimise the risk of recurrence, further control valves have been installed.

*95th Annual Report on Alkali, etc. Works by the Chief Inspectors, 1958. H.M.S.O., 3s. 6d.

Thorium in Canada

THE world's first installation to recover thorium from the waste liquors produced in uranium milling began production in Canada recently. Built at Elliot Lake, Ontario, at a cost of about $1 million, the plant is designed to produce some 150 tons p.a. of thorium salts. The operators, Rio Tinto Dow Ltd., are on a good thing from the economic point of view, because mining, crushing, grinding and leaching will have to be carried out anyhow in the adjacent uranium production operations, so the cost of thorium recovery will be low.

Solvent extraction is used in the process, the waste liquor from uranium processing being passed in acid solution through a series of treatment tanks and mixers, the precipitated salts then being separated out, dried and calcined. The thorium recovery process was developed by the Dow Chemical Co. Ltd. who, along with Rio Tinto Mining Co. of Canada Ltd., commissioned the plant. The main contract for the plant went to Humphreys & Glasgow (Canada) Ltd.

Glass lock-up for atomic wastes

THE burning problem of radioactive waste disposal in atomic energy plants has brought forth a variety of ideas of which the most immediately useful seems to be concentration of the wastes followed by underground storage in stainless-steel tanks. To the tidier mind, the idea of locking up these wastes by chemical combination with some reliable solid material such as Montmorillorite clay, glass or ceramics, which can then be buried, seems more attractive as well as more reassuring. Various investigations are proceeding on these lines.

In Canada, encouraging progress has been made in the fusing of fission products with nepheline syenite (a locally available silicate) and lime to form glass. At the Chalk River, Ont., research centre of

Atomic Energy of Canada Ltd., they take heated radioactive waste, concentrated in a solution of nitric acid, and feed it into melting crucibles with syenite (which constitutes 85% of the mixture) and lime (15%) to form a highly porous gel from which water and nitric acid can be driven off. Denitration is complete at 900°C., and further heating to 1,350°C. causes the gel to melt. Slow cooling effects annealing of the glass. Gases evolved in these operations are treated in adsorbers to remove ' volatile radioactivity ' and undergo further treatment by condensation, scrubbing and filtration.

Further details were given at a recent meeting of the Chemical Institute of Canada by A. R. Bancroft, according to whom the process is very attractive economically.

Petrochemicals in Europe

SINCE 1943, when Western Europe's first petrochemical plant came on stream, $775 million have been invested in the petroleum chemicals industry, in terms of plants in operation. This is an increase of more than $225 million, or approximately 40%, since the end of 1957. Investment is expected to rise even more rapidly to over $1,600 million by the end of 1961. Most recent newcomers to the petroleum chemicals field are Belgium and Denmark, while Austria is expected to set up an industry soon.

These facts were reviewed by a working party of the O.E.E.C. in Paris recently, when it was revealed that the total carbon content of petroleum chemicals produced in member countries rose from some 630,000 tons in 1957 to 813,000 in 1958, and is expected to increase by a further 50% to 1,225,000 tons in 1959.

This growing level of production will necessitate vastly increased quantities of raw materials and a total of about 5 million tons of liquid and gaseous feedstock is expected to be required in 1959. Products where output will be appreciably expanded include synthetic rubbers of various types, plastics materials (mainly polythene and polypropylene), ethylene oxide derivatives and solvents.

Experimental gas cleaning

RECENT gas-cleaning experiments by the British Iron and Steel Research Association include pilot-plant studies aimed at finding a way to clean gases containing iron oxide fume without incurring high capital or running costs. Various forms of fume-cleaning systems of the wet-scrubber type have been studied.

Experiments on a Pease Anthony venturi type of wet scrubber have shown that, when water is injected at right-angles to the gas stream near the throat of the venturi, fume-collection efficiencies of up to 95% can be obtained. Under these conditions the pressure drop across the venturi section is about 30 in. w.g. An alternative to the venturi-tube scrubber section has been developed in which a straight tube is used and a water spray is injected concurrently with the gas stream. Efficiencies of up to 97½% have been obtained. Not only is there no pressure loss across the scrubber section but the ejector action of the concurrent water spray can be used to draw gas through the cleaning system. The power required to produce the water spray may be greater than the equivalent fan power required to overcome the pressure drop across the venturi-type scrubber section. However, since low-pressure steam may be used to atomise the water spray, the maintenance and operating costs of this system in a steelworks may be well below that for the fans needed with the venturi scrubber section. A pilot plant is being considered with a view to the further development of the system.

These activities are mentioned in the annual report of B.I.S.R.A., which also refers to some experiments on the measurement of heat (or mass) transfer making use of the quantitative analogy which exists between the convective transfer of heat, mass and momentum between a stream of fluid and its boundary surface. The transfer of momentum results in a shear force at the boundary surface which is termed ' skin friction '; measurement of this force thus provides a method of analysing heat- and mass-transfer phenomena.

New journal 'gets weaving' on fibres and plastics

IN recent years fibres and plastics have become interwoven in more senses than one, for since the advent, first of semi-synthetic resins and then of entirely synthetic ones, for use in the form of fibres, certain aspects of the plastics industry have become increasingly associated with the fibres field. Moving with the times, the monthly technical journal *Fibres International* has now widened its scope to include certain aspects of the plastics industry. With its current (July) issue it ' gets weaving ' under the new title of *Fibres & Plastics*. In this issue an introductory article examines various ways in which fibres have been joined with plastics in products for industrial and consumer use, while an article by A. J. Hall, B.SC., F.R.I.C., discusses the combination of fibres and plastics used in some of the new forms of textile materials. A further article, entitled ' Static—Your Problem,' discusses the problems of static electricity in textile materials, plastic films and fibres-and-plastics used together. In addition, there is an illustrated preview of the International Plastics Exhibition.

Today, combinations of fibres and plastics range from plastic-coated textile materials to fibre-resin laminates, used, among other things, for chemical plant. From these developments we can see the formation of a new, rapidly growing branch of industry, and *Fibres & Plastics* is to be congratulated for its enterprise in seeing the possibilities of this field.

Fibres & Plastics makes a special offer to readers of CHEMICAL & PROCESS ENGINEERING: so that they can see for themselves the latest trends in fibres and plastics they are invited to send for a free specimen copy of the journal. Applications should be made to *Fibres & Plastics*, Leonard Hill House, Eden Street, London, N.W.1.

Solvent extraction in lactic acid purification

THE new lactic acid purification process developed at the Widnes (Lancs.) works of Bowmans Chemicals Ltd. is believed to be an entirely new approach. Based on solvent extraction, the process is carried out in a plant which cost something under £25,000 to build.

Bowmans produce lactic acid by the anaerobic thermophilic fermentation of sugars at 50°C., the product being a dilute calcium lactate containing a number of complex impurities. The conventional purification process involved an elaborate sequence of coagulation, decolorisation, acidification, removal of heavy metals, and evaporation under vacuum, some of these processes being repeated. In the new method the dilute calcium lactate from fermentation, after removal of bacterial protein, is acidified and calcium is removed as the sulphate. The dilute lactic acid is then decolorised in activated carbon columns which are regenerated in sequence.

After purification, the acid is evaporated under vacuum and the product extracted in countercurrent with isopropyl ether as the solvent. Enriched solvent is then re-extracted in countercurrent with distilled water.

From the extraction tower onwards the acid is handled in glass, stoneware, plastic or rubber-lined equipment. Development of the plant from the laboratory to the present stage has taken three years.

High-efficiency pulping

AN unusually high efficiency rate of more than 90% recovery and re-use of pulping chemicals in its prehydrolysed sulphate process is a feature of the new $20-million pulp plant of Buckeye Cellulose Corporation at Foley, Florida. In normal operation, the recovery rate is expected to exceed 95%. Basis of the system is a standard Babcock & Wilcox heat and chemical recovery unit, followed by a venturi scrubber-cyclone separator unit. The system is claimed to be unique in that recirculated liquor (65%) and also make-up liquor (50%) are sprayed into the twin scrubber sections through separate headers.

Also incorporated in the new mill is a double screening system for the removal of undesirable particles prior to bleaching. With the new system, every fibre passes through at least two sets of screens before bleaching treatment.

With the new mill, Buckeye has doubled the original capacity of its five-year-old wood pulp plant at Foley to 200,000 tons p.a. of dissolving pulp, or 266,000 tons of paper pulp. The new mill is integrated with the original one in a semi-independent tandem arrangement. Both mills employ a special seven-stage bleaching process. Since its installation in 1954, the process has been continually improved, including the addition of two chlorine dioxide bleaching stages, the use of new chemicals, and the addition of auxiliary equipment for greater precision in the control of temperature and concentrations. Details of this process are secret.

Leading the way to new alloys

NEW corrosion-resistant materials for the chemical and other industries, and more effective shielding against radiation in nuclear applications, may result from recent research in the United States. This has pointed to the feasibility of producing 'lead-cemented' alloys of cobalt, copper, iron, molybdenum, nickel, tungsten and other metals by mixing molten lead with finely solid particles of the other metal. The result is a material combining the properties of both.

For instance, lead is effective in stopping gamma rays when used in nuclear radiation shielding. With boron added by the new process, there would be an effective barrier against the passage of neutrons—also a product of radiation. For chemical engineering applications, some useful alloys might be developed combining the corrosion resistance of lead with the strength of other materials. Other possible combinations suggest gaskets for use in temperatures which would burn up plastic gaskets.

Lead's softness, sometimes a disadvantage, can be an asset with the new alloys. The lead could serve as a binder for dispersing in mixtures containing less ductile materials like tungsten or materials with properties of special interest, such as very fine iron powder with its unusual magnetic properties.

Experiments have been carried out at the Battelle Memorial Institute, Columbus, Ohio, under the sponsorship of the U.S. Lead Industries Association. Novel methods have been developed for making the unconventional alloys. When large amounts of powdered solids are added to molten lead, the mixture becomes sluggish. A revolving crucible, resembling a cement mixer, was designed to meet this situation. It was found that most metals resist being stirred into molten lead. Special pretreatment of these powdered metals and special mixing techniques were devised. After the hot mixtures were poured into moulds for quick hardening, the moulds were vibrated to minimise porosity.

Experiments show that the size and shape of the metal powder particles, as well as the amount, affect the final material.

In search of inventors

THE collective inventive faculty in any country is amongst its greatest assets; the key to its stimulation and development remains a tantalising mystery to which many a research director must have devoted deep thought. Those sudden bursts of inventive genius, springing from the subconscious depths of the individual, have yet to be satisfactorily analysed by the psychologist.

Adam Smith had at least one very simple prescription for stimulating invention; namely, his famous doctrine of division of labour. These days, however, it is not so easy to see the connection, for the doctrine has led to extremes of specialisation that seem more likely to discourage than to enkindle originality.

It would be interesting to discover whether originality of thought thrives better in a socialist

community than in a capitalist one. Certainly in the U.S.S.R. they seem to attach great importance to the artificial stimulation of invention, and from time to time competitions are organised with a view to discovering latent talent and to enlarging that special class of mortals, known as ' innovators,' that seems to occupy an increasingly important position in Soviet industry. There are other groups, too, whose purpose is to encourage the workers to think out new ideas, and so earn the admiration of their fellows, like the exemplary ' Heroes of Labour.'

One recent competition, announced in the Russian chemical industry journal *Khim. Promyshl.* last December, was open, over a period of six months, to all young workers, students and innovators in the chemical, gas and petroleum industries. A large number of ministries, boards and research institutes co-operated in its organisation. The prizes include 15 ' firsts ' (a piano or a motor-cycle), 25 accordions, sporting rifles or television sets, and 50 cameras, wireless sets or other prizes. The scope of the competition is practically everything that makes for improved efficiency in production, lower cost, better quality or new products. There appear to be four main categories: (i) general technology and equipment; (ii) building design and layout in chemical and allied projects; (iii) research institutions, their instruments and equipment; and (iv) planning boards and centres, including means for reducing the cost of building and equipping new works. All these categories are elaborated upon to a degree which must overawe the youthful inventor.

It is doubtful whether, from the strictly materialistic point of view, a piano or a motor-cycle is adequate incentive to a young man (or woman) to become the genius behind a new design of machine, a highly efficient production line, or a marvellously transformed planning department. But it might be said that, particularly as the proud possessor of a new piano, he will henceforth become a ' key ' man, adding greatly to industrial harmony. The piano, at least, should strike a responsive chord.

' Terylene ' and glass-reinforced plastics

THE use of *Terylene* as a protective layer on structures made of glass-reinforced plastics is an interesting development which might well answer the problem of improving the appearance, abrasion resistance and limited weather and chemical resistance of such structures. If so, it should open up a whole new range of applications for glass-reinforced resins, which are certainly attractive from the point of view of their very high strength/weight ratio.

Even more interesting to the chemical engineer is that, for optimum chemical and abrasion resistance, *Terylene* alone can be used to reinforce the resin. The use of a *Terylene* fabric woven from twistless, high-tenacity filament yarn enables a laminate to be made with a tensile strength higher than that of a resin reinforced with glass chopped strand matt but lower than that of one reinforced with woven glass fabric. Laminates of this type have been used under very severe chemical conditions, *e.g.* where the laminate is in contact with hydrofluoric acid, and have performed very satisfactorily.

According to the Fibres Division of I.C.I. Ltd., the impact resistance of a polyester resin reinforced with a fabric woven from twistless, high-tenacity *Terylene* yarn is also considerably higher than that of a resin reinforced with either glass fabric or chopped strand matt.

Wood makes a come-back

WOOD, that venerable material of construction which in recent years has been eclipsed in so many of its applications by such materials as plastics and light metals, is now a subject of experiments aimed at overcoming its natural disadvantages, *e.g.* its tendency to warp, split and show lack of dimensional stability.

One approach is the chemical modification of the structural components of the wood cell walls for the purpose of modifying its overall properties. Within recent years, this aspect has been applied in particular to an improvement in the dimensional stability of wood and has been demonstrated to be practicable in a series of esterification and etherification reactions. By such treatments, some of the hydrophilic hydroxyl groups of cellulose and the hemicelluloses and of lignin are replaced by more bulky and less hydrophilic groups.

In addition to improving resistance to swelling and shrinkage, substitution of the hydroxyl groups in the cell wall structure can result in improved resistance to biological attack by interference with the enzyme systems responsible for the biological attack and can reduce the combustibility of wood, under suitable conditions.

Experiments have been carried out at the Arthur D. Little Research Institute, in Scotland, using cotton cellulose and beechwood sawdust. Attempts have been made to prepare a series of esters and ethers of wood. The main limiting factor in such reactions is the sensitivity of the wood structure to aqueous alkaline or mineral acid media.

By trying out a wide selection of reagents the Institute hopes to arrive eventually at a single treatment which would produce a chemically modified wood with attractive technological properties and also resistant to decay, insects, fire and changes in dimensions with changes in humidities.

'CPE' AND THE PRINTING DISPUTE

Circumstances over which we have no control, arising from a dispute in the printing industry, delayed the production of CHEMICAL & PROCESS ENGINEERING *this month and oblige us to present a reduced edition. We shall return to 'full' issues now that the dispute has been settled and normal working is being resumed.*

The Chemical Engineer in Charge of a Development Section

By F. Roberts, B.Sc., F.R.I.C., A.M.I.Chem.E.

Chemical engineers are becoming more widely employed in industrial and government research, and also in development and technological departments. The latter establishments are usually linked with chemical plant design offices or chemical works. This article discusses some aspects of the job of running a section which develops new processes, obtains technical data for a design office or investigates possible improvements into existing processes. Such a section often contains chemists, engineers and physicists, and the officer in charge must be able to make full use of this range of experience.

THE method of grouping staff in a development or technological department naturally varies from place to place. Although some of the titles vary, the 'family tree' generally conforms to the scheme shown in Fig. 1. An executive cannot efficiently control a department if more than four or five people report directly to him, and authority is normally delegated to conform to this rule. The head of department controls a greater number of people because he shares many of his day-to-day duties with his deputy.

Often three or four section leaders report to a group manager, and the latter is generally a member of the management committee, which is chaired by the head of department. The various sections can only operate efficiently by co-operating with the information, engineering and administration groups, for it would be uneconomic to decentralise these important services to research and development.

Working with committees

The work of a development section frequently originates from the committee responsible for some new project, and the chemical engineer in charge of the appropriate section will generally attend the meetings of the committee. Dates for completion of the work will often be fixed by the committee at an early date, somewhat to the dismay of the man responsible for getting the job done. He should never make wild promises. If after careful study it appears that the target dates cannot be met, this fact should be reported early to the committee, with reasons, so that the overall programme of the main project can be adjusted. The usual way of reporting important information to a committee is in the form of a paper, issued in advance of a meeting, so that members can come along prepared for discussion of the topic.

Although interim reports can be issued to the committee to facilitate its work, the chemical engineer should never quote experimental results before these have been confirmed and evaluated. A golden rule is never to quote any results obtained the day before the meeting!

Finally, the man responsible for the work should not allow a committee to tell him how to perform experiments —he must insist on the right to plan his own work.

Starting the job

The first and foremost thing any section leader should do in mounting a new job in the laboratory is to brief the team as fully as possible. The staff should be given a programme in outline and invited to fill in details, or to make additional suggestions for obtaining the answer to the problem. The leader must bear in mind the degree of experience of the various members of his team in deciding which suggestions to accept and which to discard. The more scope and freedom which can be given to the men doing the actual work, the more enthusiasm will be forthcoming from them. This should result in provoking original thinking and ensuring loyal co-operation.

Drawing up a programme

A section leader will not obtain good results from his staff if he only throws out vague proposals for the work to be done. He should provide a programme in writing or, alternatively, record and circulate an itemised programme prepared as the result of group discussion.

Finally, a *detailed* programme of work will be prepared, and this should include:

(i) Aims and objects.
(ii) Time scales (if any).
(iii) Known facts, and the nucleus of any literature survey.
(iv) A list of the variables to be investigated, and an outline method for any necessary calculations.
(v) Services to be 'laid on,' such as design or drawing office help, analytical laboratory assistance or the purchase of new items of equipment.
(vi) The number and names of the staff officers who are to carry out the programme.
(vii) Allocation of laboratory space.

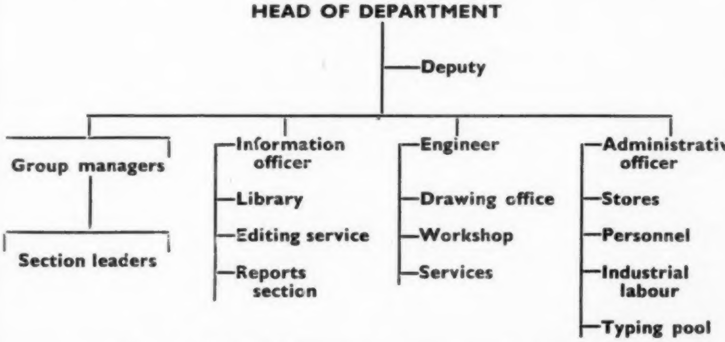


Fig. 1. Typical scheme for a development organisation

Progressing work

In any well-run organisation it will be found that the rule 'One man, one boss' is in force. This rule should also be adhered to throughout research and development establishments. Section leaders should always insist on controlling their team personally; confusion and lack of discipline inevitably occurs if group managers issue instructions direct to personnel in the laboratories. Comments made to junior staff by senior personnel during a visit to the laboratory should be carefully phrased; any proposed change of plans should come through the section leader. Thus, only the section leader should issue instructions, so that he knows exactly what work each man has on hand, and he will then know the amount of progress to expect in a given period of time.

It is also a sound plan to give a person a job and leave him to it. A competent worker is likely to become unco-operative if his superior is constantly breathing down his neck. The frequency at which verbal progress statements may be called for must vary according to the individual circumstances. In the case of inexperienced junior staff, however, discussions in the laboratory two or three times a week must be the rule. Much depends on the degree of practical experience of the individual members of the team.

Section meetings should be held at least once a month and, occasionally, twice a month. These occasions should be kept informal, to create an atmosphere in which frank and earnest technical discussion can take place. Each meeting may be concerned with one aspect of the work of the section, and the scientist who is carrying out this work can be expected to make a brief statement, which should be followed by a general discussion. It may be helpful for someone to keep notes of the meeting, for reference purposes.

Reporting the work

As stated earlier, a design office is often the recipient of information provided by a chemical engineering development section. A synopsis of the results may be reported verbally, when these have been well substantiated, but a formal technical report will also have to be prepared. Considerable space would be taken up here if an attempt were to be made to review in detail the principles of good report writing. Each establishment has its own format, to which all sections must adhere. In general, the report should always be prefaced with an abstract or summary. The first part of the report proper should be an 'introduction' including a clear statement on why the work is being done, and another statement giving the objects of the work; earlier work of a related character can also be summarised here. The next sections can be 'theoretical,' followed by 'experimental,' after which the 'discussion' will come. The report should terminate with 'conclusions,' which should preferably be itemised and kept as brief as possible to ensure the greatest possible clarity. Necessary tables, calculations or graphs should be attached to the report in the form of appendices. There is no short cut to becoming a good report writer; it requires a good deal of patience and practice. (It is probably the *last* thing that the chemical engineer becomes proficient in after he has entered the profession.) Junior staff naturally dislike seeing their reports altered and rearranged by superior officers. However, the solution lies in the hands of the junior himself, and he will not become proficient until he takes a real interest in writing a good report for its own sake.

Improving the efficiency of the section

Having seen how a development section could be organised in order to function smoothly, some ways of improving its efficiency can now be considered.

Although the various members of staff will have had technical training up to various levels, it is nevertheless good practice steadily to extend the education of all ranks. The more junior staff should regularly attend evening classes and perhaps part-time day classes: senior staff occasionally attend special courses in administration and management.

Professional institutions frequently run short courses on specialist topics and also organise symposia for the presentation and discussion of technical and scientific papers. Most establishments will permit a number of their appropriate staff to contribute to, or attend, such functions. Contacts are thus made, both formal and informal, with workers in similar fields of investigation. On occasions, large establishments have derived benefit from organising extended series of colloquia within their own walls. This is sometimes useful if problems of commercial and state security prohibit a wider forum. In a wider sense, this need for a continuing education and stimulation of the scientific mind can be fulfilled by visits to other establishments and laboratories. Discussions with visitors to one's own laboratories also help to create new ideas. However, there can sometimes be a tendency to overdo this mutual 'rubber-necking,' as it has been colloquially referred to. The section leader must make a reasonable allocation of his working hours, for playing host takes time and effort, and outside visits mean a further loss of time from the daily work. Outside duty also involves subsistence and travelling expenses, and a further loss in man-hours is involved in the preparation and submission of claim forms.

The morale of the section must always be kept at a high level if trained staff are to be retained. A continual turnover of staff in a research and development organisation causes a heavy drain on efficiency. Although a chemical engineer carries his *basic* knowledge around with him wherever he goes, there is generally a considerable amount of *specialised* experience to be acquired by him before he becomes really useful to a new employer.

Great care has to be taken in selecting new staff. Not only must management be certain it is offering jobs to the right men, but the would-be employee must be made quite clear as to the sort of work and responsibility entailed in the proferred appointment. Thus it is very important at the original interviewing board to allow candidates plenty of time for *asking* questions as well as *answering* the board. If it is possible to arrange an informal tour of the laboratories, this will be valuable in giving a further opportunity for both sides to look at each other.

The members of a section engaged on chemical engineering development or similar work must be kept aware of policy at the highest levels of management. They must feel that there is always plenty of new and interesting work coming into their establishment. The prestige of their laboratory in scientific and technical circles must be high. Finally, they must always feel that they can discuss with their superiors any personal problems which arise, and that strenuous attempts will automatically be made to assist them. The problems which arise most commonly are either domestic, such as housing, or professional, *e.g.* a desire to transfer to other work.

Although the time consumed in

(*Concluded on page* 244)

Continuous Tar Distillation in Canada

Latest continuous distillation techniques bring higher output and lower operating costs in the manufacture of coal-tar products.

CANADA'S first continuous tar distillation plant, with a rated capacity of 15 million gal. p.a. of tar, was recently brought into operation at Hamilton by the coal-tar products division of Dominion Tar & Chemical Co. Ltd. The plant produces distillates and pitches for a variety of industrial uses. Features of this operation include:

- ★ The tar distillation unit and steam plant can be operated by only three men, plus three others for handling operations, whereas a batch plant of the same capacity would need 25 operators.
- ★ Continuous viscosity measurement of the pitch produced improves control and simplifies testing.
- ★ Special effluent-treatment arrangements deal with oil and phenolics in the process water effluent.
- ★ Most products from the plant solidify at normal ambient temperatures, so a continuous supply of steam is necessary.

Treatment of crude tar

The plant receives coal tar from nearby steelworks coking operations, tar being segregated by grade in storage and blended as needed for pitch production in four 250,000-gal. feed tanks for the distillation unit.

In general, the lighter fractions of coal tar are distilled off, leaving a residue of coal-tar pitch. The grade of pitch required governs the operation. Higher-melting-point pitches require the removal of more distillate and *vice versa*. The distillates removed contain the chemical components of tar that are normally extracted. These are fractionated to concentrate tar acids, naphthalene and creosote in three fractions.

Crude tar containing 1 to 3% water is heated in the convection section of an oil-fired tube heater and again in a trimming heat exchanger and fed to a dehydrating column, where water and light ends in the benzene, toluene and xylene range are removed as overhead. The water is decanted to waste treatment and the light oil pumped to storage.

Naphthalene removal

The dry tar from the bottom of the dehydrating column is pumped back through the radiant section of the tube heater and flashed into the bottom of a multi-plate fractionation tower. The overhead from this tower is in the solvent naphtha range and contains the tar acids and coumarone-indene resins. Two side draws are taken, one highly concentrated naphthalene, and the second, oils boiling in the creosote range. Heat is recovered from the creosote fraction by exchange with the feed tar.

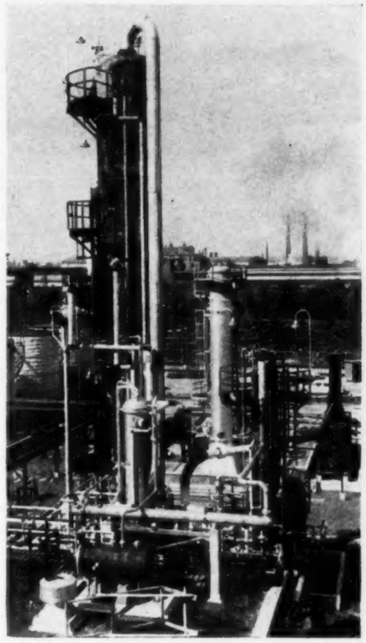
Details of column

The column operates at a high vacuum provided by a two-stage steam ejector. The melting point of the pitch residue in the bottom of the column is controlled by the temperature of the feed tar and the creosote draw-off. The products are pumped to storage.

The above equipment is fabricated of mild steel and 316SS stainless steel according to the degree of corrosion resistance required. The main source of corrosion is small amounts of ammonium chloride in the feed tar which decompose in the upper half of the column. Caustic soda is metered into the feed tar stream to neutralise this. For higher-melting-point pitches, the residue from this still is passed through a second heater and the pitch topped off to the required melting point. Most of the products from the still solidify at room temperature and transfer piping for these is steam traced internally and insulated.

Analytical control

Controls for the distillation unit are assembled on one main panel in the control room adjacent to the pump house. A small test bench is also located here so that routine control analyses can be made on the spot by the operators. Pitches are usually identified and sold by their melting point. Several empirical methods are used to determine melting points, but basically these are a measure of the viscosity of the pitch under specified conditions. Continuous viscosity measurement has been installed on



Stills, vessels and storage tanks at the Hamilton continuous tar distillation plant.

this unit, the sensing unit being an ultrasonic vibrating probe in the pitch stream which continuously compares the viscosity of the pitch produced with a standard sample held at the same temperature.

Pitch product is pumped to 50,000-gal. storage tanks. Pitch from the still passes through a water-cooled heat exchanger, which reduces the temperature from 340 to 230°C.

The light distillates containing tar acids and naphthalene are shipped to the Toronto plant for further processing. The heavy distillate is blended to form creosote. In volume this amounts to about a third of the tar processed.

Effluent system

In the design of the plant, pollution control was a primary consideration. A separate drain system picks up all waste process water which passes first through an A.P.I.-type separator to remove oils down to 10 p.p.m. From here it is pumped to two 12,000-gal. storage tanks for surge control and then to a biological treatment tank for the removal of phenolics. The effluent from this tank contains no more than 1 p.p.m. of phenolics starting with a feed of up to 1,500 p.p.m. The biological unit will destroy 150 lb./day

of phenols. This dephenolised effluent is further diluted with clean waste water to the required limits of 20 parts per billion of phenolics.

To eliminate air pollution, all product tanks containing hot pitch are vented through oil seals to knock down any fumes.

Design and installation

Overall design of the plant was produced by the company's engineering staff with the distillation unit designed and installed by the Canadian Badger Co. Ltd.

COMPANY NEWS

Albright & Wilson Ltd. announce plans for the further expansion of their activities in Canada. The Electric Reduction Co., their Canadian subsidiary, has purchased a modern fertiliser plant at Port Maitland, Ontario.

The plant is that of Dominion Fertilisers Ltd.; it produces phosphatic fertilisers. The activities of the plant will be linked with the new $10-million chemical project at Port Maitland.

Albright & Wilson announced two months ago that 'Erco' would build new plants to produce phosphoric acid, sodium phosphates and other products.

*

Hess Products Ltd. and the chemical division of Armour Chemical Industries Ltd. have been merged under the name of Armour Hess Chemicals Ltd., of which half the share capital is controlled by Armour & Co. of Chicago, whilst the other half is controlled by United Kingdom interests, including a substantial proportion by Associated Chemical Companies Ltd.

Hess Products was formed in 1946, and acquired patent rights for the fractional distillation of fatty acids from Armour & Co. of Chicago. Since 1956 Hess Products has also manufactured the bulk of the industrial chemicals sold by Armour Chemical Industries Ltd., London.

The board of Armour Hess Chemicals Ltd. is as follows: Mr. A. Henderson (chairman), Mr. N. Hess (managing director), Mr. J. T. Barrie, Mr. J. W. R. Hudson, Mr. M. E. Lewis (U.S.A.), Mr. E. J. McAdams (U.S.A.), Mr. M. K. Schwitzer and Mr. E. W. Wilson (U.S.A.).

*

In connection with the projected expansion of their existing chemical plants, and diversification of their activities in the chemical field, British Celanese Ltd. have set up a chemical sales development section.

ORDERS and CONTRACTS

John Dalglish & Sons Ltd. have in hand a contract for four large synthetic rubber drying machines for the Japan Synthetic Rubber Co. Handling GR-S rubber, each machine produces 5,500 lb./hr. of dry product.

The air conveyor distributes the wet material evenly on the stainless-steel conveyor and it is partially dried in its passage along the first layer of the drying machine, is then doffed and falls on to the second conveyor which carries it through the machine in the reverse direction. This process is then repeated and the dried product is finally delivered to a screw conveyor system at the bottom level of the machine.

Special precautions are taken for even distribution of the drying air and for controlling and recording the temperature in the various sections. Talc dusters are fitted to the feed end of each conveyor to prevent rubber adhering. Each machine is 60 ft. long, 10 ft. wide on the conveyor, and 25 ft. high. The initial moisture content varies between 43 and 54% and the final moisture content is 0.2%.

*

Three miles of carbon-steel tubing were used in each of the air blast coolers recently completed by Spiro-Gills Ltd. for the Kuwait Oil Co. Ltd., for installation in their first natural-gas injection plant. Some 86,300,000 cu.ft./day of natural gas will be cooled, at pressures of 1,200 p.s.i.g. and 2,600 p.s.i.g. respectively, in the 'inter' and 'after' coolers. The gas will be cooled from 283 to 140°F. in the 'inter' cooler, and from 296 to 144°F. in the 'after' cooler.

The tubes, arranged in three sections, are wound with flat helical aluminium gills, to give a total surface area of 72,600 sq.ft. Four 10-ft.-diam. fans will deliver 430,000 cu.ft./min. of air at atmospheric temperature (approximately 120°F.) to each cooler.

*

An order for a glass chlorine cooler with a cooling surface of 2,400 sq.ft. and capable of cooling 40 metric tons/day of chlorine has been received by Q.V.F. Ltd.

Worth £10,924, the apparatus comprises 40 × 60 sq.ft. glass coolers mounted in four vertical banks. It is for delivery to Cellulosa Argentina, of Buenos Aires.

*

As a result of negotiations with the Polish Government agency Centrozap and following visits to Poland by members of the company's staff, an order has been placed with the Head Wrightson Machine Co. Ltd. for two hot-dip tinning lines, valued at approximately £180,000 and designed to give an average output of 10,000 tons p.a. of tinplate.

The plant consists of two 2-way tinning lines incorporating provision for automatic feeding, final inspection, sorting and packing in the lines. In addition the company are providing the engineering details for the auxiliary equipment which includes palm-oil storage and preparation tanks, acid tanks, cooling and cleaning, air blowers, fans, ducting and fume exhausting.

*

An order has recently been placed with the drier and gas plant division of Birlec Ltd. for two driers to be supplied for the Italian nuclear power station under erection at Latina. To be installed in the main reactor cooling circuits, they will remove water vapour from the carbon dioxide gas used in the heat-transfer system.

*

Atomic Energy of Canada Ltd. has awarded a contract for the design, fabrication and construction of a heavy-water fractional distillation plant to Canadian Badger Co., Toronto. The plant will be constructed at Chalk River, Ontario, and will be used to reconcentrate heavy water supplies that have been down-graded by light water contamination. The distilling equipment has been especially designed to minimise loss through leakage or vaporisation of the $28/lb. heavy water processed in the unit.

*

The chairman and managing director of George Fletcher & Co. Ltd. recently went to Russia and negotiated an order valued at £150,000. The order includes 20 crystallisers and 15 vacuum pumps for use in existing beet sugar factories in Russia, and is part of an order worth £1½ million which was negotiated by Booker Bros. McConnell for their Engineering Group.

The Russian sugar industry will require 80 new factories in the next few years and it is understood that their own engineering workshops can only manufacture the machinery for a relatively small proportion of their requirements.

*

Electro-Chemical Engineering Co. Ltd., a subsidiary of Efco Ltd., have received an order from Japan to supply an electro-metallurgical plant. The contract price is more than £300,000.

Theory and Design of Pneumatic Transport Systems—I

By H. Bannister, Ph.D., M.Sc., D.I.C., A.M.I.Chem.E.

In our September 1958 *issue an article on 'Pneumatic Handling of Bulk Materials,' by W. Farnworth, discussed the practical aspects of pneumatic transport. The article below examines the state of the scientific literature on pneumatic systems. It is shown that formulae and correlations of variables based on empirical relationships still provide the only means available for design.*

THE utilisation of air streams in pipes to transport granular solid materials was already established firmly as a well-tried and reliable industrial tool long before scientific enquiries into its mechanism were undertaken. F. E. Duckham[1] describes a vacuum elevating plant with a capacity of 200 to 600 tons/hr. which was operating successfully in London Docks in 1892. Sturtevants described an American plant for handling dust in 1866 and Hudson[2] states that by 1900 plants were operating in many parts of the world. It is worth recording that the Boots organisation had a 20-tons/hr. ash handling plant at their Nottingham factory in 1918. Most of these plants worked on the suction principle and cereal seeds were found to be the easiest materials to convey. However, ash and clinker, coal, sand and gravels were all successfully handled where the material was dry enough to be free-flowing.

Early theoretical work

The earliest reference found by the author dealing with pneumatic transport from a scientific viewpoint is that of Bentham (1916)[3], but undoubtedly pride of place must really be given to W. Cramp (1920-25),[4] later joined by Priestley.[5] In a series of carefully conducted investigations these scientists laid the theoretical foundations upon which much subsequent work was based. As one would expect from the practical applications, most of the early work was concerned with cereal seeds. According to Cramp, the force on an individual particle was proportional to:

$$\alpha(V_a - V_g)^2$$

where V_a and V_g are the linear velocities of air and seeds and α is a constant having dimensions M/L; α can be determined simply by practical measurements and Cramp states that the expression for flow in a vertical tube

$$\alpha(V_a - V_g)^2 - W = \frac{W}{g}\,\frac{dV_g}{dt}$$

can be integrated, assuming that α and the air density remain constant, giving

$$\left[\frac{V_a}{\sqrt{w/\alpha}} - 1\right] \log_e \frac{V_a - \sqrt{w/\alpha}}{V_a - V_g - \sqrt{w/\alpha}} - \left[\frac{V_a}{\sqrt{w/\alpha}} + 1\right]$$

$$\log_e \frac{V_a + \sqrt{w/\alpha}}{V_a - V_g + \sqrt{w/\alpha}} = 2g\frac{\alpha}{w}s$$

where s = distance travelled by particle, g = acceleration due to gravity and w = weight of one particle.

Cramp regarded the ratio $\sqrt{w/\alpha}$ as a very important parameter for particles in pneumatic systems.

Empirical formulae

Perhaps the most important aspect of Cramp's expression is that even an early investigation like this yielded a mathematical statement as complicated as the one given. This comparative difficulty in expressing the relationships found in pneumatic transport is seen as a thread running through all subsequent work and persists today. About this time Gasterstädt (1924)[6] provided some empirical formulae which resulted from his experiments. These are sometimes useful in design work because they do enable fairly easy cases to be assessed. When used for highly angular and non-free-flowing materials, however, the pressure values are too low

$$F = \frac{F_m}{F_a} = \frac{R}{K} + 1 \text{ and } F_m = F_a\left(\frac{R}{K} + 1\right)$$

where F = friction ratio, F_m = friction when handling material, F_a = friction when handling air, R = ratio of lb. of material to lb. of air and K = a constant obtained from the table below:

Velocity, ft./min.:	2,000	3,000	4,000	5,000	6,000
K	1.15	2.14	3.11	3.5	3.5

The velocity is that of the air referred to the empty pipe under conveying conditions. Gasterstädt also gives

$$F_g = 2.25\ Rp$$

where F_g = pressure loss due to acceleration (in. w.g.) and p = velocity pressure (in. w.g.). He stated that, when conveying wheat, a solids/air ratio of 12.5 could be maintained and that at 3,600 ft./min. a pressure drop six times that with air alone was found.

Experimental data for grain elevator

Cramp and Priestley[5] continued their experimental work and developed an expression for a vertical grain elevator. It is important, however, not to use relationships of this kind for calculations outside the range of the experimental work:

$$\text{Pressure drop in vertical tube} = \frac{L}{F}\left\{\frac{V_f}{g} + \frac{\beta}{KV_f}\right\}$$

where
L = weight of grain passing per second
F = cross-sectional area of tube
V_f = final grain velocity
g = acceleration due to gravity
s = pipe length
$K = \dfrac{\text{average grain velocity}}{\text{final grain velocity}}$ (0.8 for many pipe lengths between 30 and 60 ft.)

also $\beta = \dfrac{w + f_g}{w}$

f_g = force due to friction

w = weight of individual grains.

Ekströne (1928),[7] a Hungarian worker in this field, stressed the relationship between the pressure drop and the solids/air ratio.

Theory of horizontal conveyors

About this time it was recognised that horizontal and vertical conveyors behaved very differently and must be separated in theoretical treatment. Davis (1935)[8] felt that horizontal conveying was a much more difficult problem than vertical conveying. In making this statement he was presumably referring to the theoretical relationships rather than the power requirements. The latter are definitely in favour of horizontal transport. Davis's expressions are as follows:

$$U_o = \sqrt{\frac{V(\sigma - \rho)2g}{\rho A}}$$

$$U_o = 6.55\sqrt{\frac{\sigma d}{\rho}} \text{ for spherical particles,}$$

where U_o = minimum pick-up velocity, V = volume of particle, A = projected area of particle, σ = density of particle, ρ = density of fluid and g = acceleration of gravity.

Velocity of air in turbulent flow

It is impossible in a brief review of this nature to do justice to the impressive work of Bagnold (1936)[9] who made studies of the effect of wind on sands and desert dunes. He confirmed Prandtl's equation for the velocity distribution of air in turbulent flow parallel to a fixed surface:

$$V = 5.75\sqrt{\frac{T}{\rho}} \log_{10} \frac{Z}{K}$$

where V = air velocity at height Z from the surface, T = drag force per unit surface area, ρ = air density and K = roughness constant of dimension L. Velocity gradient V_x near surface =

$$\sqrt{\frac{T}{\rho}}$$

The distribution of turbulent flow in pipes was given by Prandtl as

$$U_{max} - U = 5.75\sqrt{\frac{T}{\rho}} \log_{10} \frac{r}{Z}.$$

Here r is the pipe radius and U_{max} is the velocity at the pipe centre line. Bagnold, using Prandtl's expression, obtained for the velocity needed to lift sand grains from a surface

$$V_t = 5.75A\sqrt{\frac{\sigma - \rho}{\rho}\, gd} \log_{10}\frac{Z}{K}.$$

Here σ is the solid density and A is the area exposed.

If in a horizontal conveyor the air velocity is gradually reduced, say by shutting the air supply off very slowly, the pressure readings begin to surge at a certain stage and more and more solid is deposited on the bottom inner surface of the pipe. The solid gathers into small dunes and hillocks which, as they accumulate, slide bodily along the pipeline. Then the dunes coalesce and block the pipe completely. This condition is quickly shown by a sudden violent rise in the pressure readings, and transport ceases.

The hopping movement of individual particles on a horizontal surface under the action of an air current applied parallel to the surface is known as 'saltation,' and is the mechanism whereby the huge sand dunes of the world's deserts were formed.

Pre-war work on fundamentals

An investigation of the fundamentals of pneumatic transport systems was undertaken before World War 2 by Bailey and Wood[10, 11] at the National Physical Laboratory, Teddington. They produced their air current by bleeding high-pressure air into the annulus of a special injector in a pipeline and they used cereal seeds as their experimental medium, thereby following the normal commercial trend. It is unfortunate that this work was not based on a more orderly approach. As it was, a somewhat strange combination of measurements was taken and there was no attempt to measure the pressure values systematically at various points along the pipeline. The air flow in the system was assessed by measurement of the pressure in the injector, which is not a very suitable method.

Influence of fluidisation techniques

After the war the science of pneumatic conveying was given a considerable impetus by demands from a different quarter. The fluidised principle of contacting gases and solids had by this time come surging into chemical engineering practice, particularly in the oil industry, and at one time looked as if it would displace all other methods of carrying out this operation. For the flow of solids through such plants to be maintained it was essential to use 'lift pipes,' 'riser legs' and other relatively short connections which were in effect pneumatic conveyors. Most pneumatic conveyors in the past had been vacuum systems, but the new demands focused attention on pressure plants since they had to transport material between plant vessels which were themselves usually under quite considerable pressure.

Isolation section

From the very ample literature of this post-war period a few typical papers will be noted. Farber's contribution[12] is important, since it gave one of the first descriptions of a 'velocity isolation section' found in the literature. Many formulae developed for pneumatic transport correlations require a knowledge of the average linear velocity of the particles and this is a quantity rather difficult to measure under normal conveying conditions. The isolation section comprises, in effect, two valves separated by a known length of piping. It should be installed in a straight pipe run clear of obstructions such as changes of section, valves, bends, etc. Some reliable method, either electrical or using compressed air, must be available for closing these valves simultaneously and very quickly. There must be facilities for closing down the rest of the transport system immediately after shutting down the isolation valves, and the velocity isolation section should be reversible in the pipeline so that a repeat test can be run to compensate for any variations in valve action. A simple calculation will then give the solids' velocity:

Let m_1 be the weight of solids (lb.) collected between valves in the forward run

m_2 be the weight of solids with the valves reversed (lb.)

f_1 be the feed rate in the forward run (lb./sec.)

f_2 be the feed rate in the reverse run (lb./sec.)

l is the distance between valves (ft.)

u_s is the average particle velocity (ft./sec.)

Part 2 of this article will deal with experimental work leading to empirical equations which are needed to design practical systems.

Then

$$u_s = \frac{2l}{\frac{m_1}{f_1} + \frac{m_2}{f_2}} \text{ ft./sec.}$$

The values found in such tests usually range from 0 to 50 ft./sec. unless the pressure conditions in the system are very abnormal, but to achieve accuracy the average of a large number of tests must be taken. In one particular set of 15 tests carried out by the present author a mean value of 25.8 ft./sec. was obtained with a standard deviation of 3.26 ft./sec. This gives an idea of the reproducibility involved.

Transport in vertical tubes

Hariu and Molstad[13] developed a theory of pneumatic transport in vertical tubes which is so typical of the approach in this period that it is worth repeating in some detail.

Over a height L of a vertical riser the pressure drop in the carrier gas is given by

$$\Delta p_x = \rho_{ds} L \times \frac{12}{62.3} = 0.1925 \rho_{ds} L \text{ or } \frac{\Delta p_x}{L} = 0.1925 \frac{G_s}{u_s}$$

It is now assumed that the Fanning friction equation applies to the energy lost by the particles in striking the walls and each other. This leads to

$$\Delta p_{fs} = 2 f_s L u_s^2 \rho_{ds} \frac{(0.1925)}{g D_r}$$

Expressing ρ_{ds} in terms of u_s we have

$$\Delta p_{fs} = \frac{0.1925 \times 2 f_s L\, u_s^2 G_s}{g D_r u_s} \text{ or } \frac{\Delta p_{fs}}{L G_s} = \frac{0.1925 \times 2 f_s u_s}{g D_r}$$

Total pressure drop $\Delta p = \Delta p_{fg} + \Delta p_{fs} + \Delta p_x$

Total solids pressure drop

$$\Delta p_s = \Delta p - \Delta p_{fg} = \Delta p_x + \Delta p_{fs}$$

Combining three of the above equations Hariu and Molstad obtained

$$\frac{\Delta p_s}{L G_s} = 0.1925 \left[\frac{1}{u_s} + \frac{2 f_s}{g D_r} \times u_s \right]$$

After the completion of their experimental work these scientists were able to determine the force on an individual particle as

$$F_p = \frac{C \rho_g (\Delta u)^2 A_p}{2g} = \pi C \rho_g \frac{(\Delta u)^2 D_p^2}{8g}$$

where C is a function of the Reynolds' number

$$\frac{D_p (\Delta u) \rho_g}{\mu_g}$$

The number of particles in L feet of riser is given by

$$N = \frac{6 \rho_{ds} L A_r}{\pi D_p^3 \rho_p}$$

The total force on all particles is

$$F = \frac{(\pi C \rho_g (\Delta u)^2 D_p^2)}{8g} \times \left(\frac{6 \rho_{ds} L A_r}{\pi D_p^3 \rho_p} \right)$$

The force on all particles in unit area of tube of length L is given as

$$\frac{\Delta p}{L G_s} = \frac{0.0045}{D_p} \quad \frac{\rho_g}{\rho_p} \quad \frac{(\Delta u)^2 C}{u_s}$$

Hariu and Molstad assumed a constant friction factor of 0.004 in correlating their work and plotted the results on the basis of the differentiated equation

$$\frac{1}{G_s} \left(\frac{dp}{dL} \right) = 0.1925 \left(\frac{1}{u_s} + \frac{2 f_s u_s}{g D_r} + \frac{a}{g u_s} \right)$$

The terminology used in their paper is as follows:

L = vertical riser height (ft.)
Δp_x = pressure drop due to solids in height L (in. w.g.)
ρ_{ds} = dispersed solids density (lb./cu.ft.)
G_s = mass velocity of solids (lb./sq.ft. sec.)
Δp_{fs} = pressure drop due to solids friction (in. w.g.)
f_s = solids friction factor (dimensionless)
u_s = average solids linear velocity (ft./sec.)
g = acceleration due to gravity (ft./sec. sec.)
D_r = diameter of riser (ft.)
Δp = observed pressure drop (in. w.g.)
Δp_{fg} = pressure drop due to gas friction (in. w.g.)
Δp_s = total pressure drop due to solids in riser (in. w.g.)
F_p = force on one particle (lb.)
C = drag coefficient $\dfrac{2F \Delta p_{fg}}{g (\Delta u)^2 A p}$ (dimensionless)
ρ_g = gas density (lb./cu.ft.)
Δu = $u_g - u_s$ (ft./sec.)
Ap = projected area of particle (sq.ft.)
u_g = gas velocity (ft./sec.)
A_r = cross section of riser (sq.ft.)
D_p = diameter of particle (ft.)
ρ_p = particle density (lb./cu.ft.)
a = acceleration of particles (ft./sec. sec.)
μ_g = viscosity of gas (F.P.S. units).

The important point about the above relationships is that some assumptions have been made in their derivation. Firstly the Fanning equation has been assumed to apply and secondly a friction factor of 0.004 to 0.0045 has been assumed. This accounts for certain failures in the work of Hariu and Molstad to explain fully cases of pneumatic transport. Nevertheless, their contribution was notable.

A further empirical approach

Another important investigation of this period is that of Vogt and White[14] who made a study of Gasterstädt and Segler's work. They arrived at the empirical formula below after considerable experimentation of their own:

$$\alpha - 1 = A \left(\frac{D}{d} \right)^2 \left(\frac{\rho}{w} \quad \frac{r}{R_e} \right)^K$$

where A and K are functions of the dimensionless group

$$\sqrt{\frac{0.33\,(w - \rho)\,\rho g d^3}{\mu}}$$

while D = pipe diameter (ft.)
d = particle diameter (ft.)
r = $\dfrac{\text{weight of solids}}{\text{weight of fluids}}$
R_e = Reynolds' number $\dfrac{D u_a \rho}{\mu}$
u_a = average velocity of fluid (ft./sec.)
w = solid density (lb./cu.ft.)

α = relative pressure drop = $\dfrac{\text{total pressure drop}}{\text{pressure drop due to air alone}}$

g = acceleration due to gravity

μ = viscosity of fluid (F.P.S. units)

ρ = density of fluid (F.P.S. units).

Vogt and White plotted

$$\log_{10}\left(\frac{\rho}{w} \quad \frac{r}{R_e}\right)$$

against $\log_{10}(\alpha - 1)$ and obtained a straight line. The trouble with this relationship is that sometimes it is difficult with the usual scatter of points that one encounters in pneumatic work to define the line exactly. This is serious when the line is nearly parallel with one or other axis, which is unfortunately the case when larger-sized materials are being conveyed.

Recent fundamental work

Perhaps the best modern approach to pneumatic conveying in the literature at present is that of Prof. Newitt and his colleagues, former colleagues and students at Imperial College.[15, 16] As a result of a considerable mathematical development, for details of which the literature must be consulted, Coulson and Richardson arrived at the following equations:

For a horizontal pipe

$$\Delta p_s A = \frac{Wl}{u_s} g\left(1 - \frac{\rho_f}{\rho_s}\right)\left(\frac{\rho}{\rho_f}\right)\left(\frac{u_f - u_s}{u_o}\right)^2$$

For a vertical pipe

$$\Delta p_s A = \frac{Wl}{u_s} g\left\{\left(1 - \frac{\rho_f}{\rho_s}\right)\left(\frac{\rho}{\rho_f}\right)\left(\frac{u_f - u_s}{u_o}\right)^2 - \left(1 - \frac{\rho}{\rho_s}\right)\right\}$$

In these equations the nomenclature is as follows:

ρ = density of fluid

u_f = velocity of fluid in conveyor

u_s = velocity of particle in conveyor

g = acceleration due to gravity

W = mass rate of solids feed to conveyor

l = length of pipe

A = cross-section of pipe

Δp_s = pressure drop due to solids in pipe of length l and section A

ρ_f = density of fluid for terminal velocities

ρ_s = density of solid

u_o = terminal velocity of particles.

F.P.S. units were used in this work.

Clark *et al.*[15] found that, in spite of the fundamental nature of the approach in these equations and the small number of assumptions which had to be made, the agreement between experimental and calculated values in Table 3 of their paper was not good. By assuming a constant solids' velocity of 15 ft./sec. they obtained a general correlation between a friction factor and a modified Reynolds' number. These workers used the velocity isolation technique already described to determine the velocity of solids in transit.

Conclusion

In spite of considerable technological effort the design of systems for the pneumatic transport of solids is not an exact science.

The situation is not unlike that in aviation and missile work where wind tunnels, some of expensive and advanced design, are still needed to elucidate aerodynamic design points. In other words, at the present time, calculation from fundamentals is not a practical approach in pneumatic conveying work.

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Chemical Engineer in Charge of a Development Section

(*Concluded from page* 238)

sorting out such problems may be irksome to the section leader, he will be assured of the loyal co-operation of his team at all times.

Safety

The key to safety in the laboratory perhaps lies in maintaining good standards of 'housekeeping.' Although a constant vigilance will be kept by supervisors for new malpractices, watch should also be kept lest a return to bad habits is taking place (*e.g.* carrying Winchester bottles without a proper container, using naked lights or smoking in a laboratory where inflammable solvents are used, or continuing to use broken or cracked equipment). Most of the points which were made about safety in the author's article on chemical plant management (CHEMICAL & PROCESS ENGINEERING, 1958, **39** (3), 94) also apply in laboratory management.

Titanium at cut prices

The largest reductions to be made so far in the price of British wrought titanium products have been announced by the Metals Division of Imperial Chemical Industries Ltd. The heaviest cuts are in prices for sheet, strip, plate and wire, which are reduced by 25%. Rod and billet prices are cut by 15%, and extrusions (latest addition to the range of I.C.I. wrought titanium products) by 12½%.

These reductions—the second in 12 months—bring the price of I.C.I. wrought titanium to less than half the level operating in 1955, when the company started commercial production.

Typical comparative prices are:

	May 1959 (*shillings per lb.*)	*June* 1959 (*shillings per lb.*)
Sheet (commercial purity), 8 ft. × 2 ft. × 20 gauge ..	111	85
Rod 1 in. diam. ..	77	66
Extrusions	120	105

The 'Odd-job Boys' of Process Development

NEW D.S.I.R. LABORATORY TAKES ON INDUSTRY'S RESEARCH PROBLEMS

The emphasis is on chemical engineering at the new Warren Spring Laboratory of the Department of Scientific and Industrial Research at Stevenage, Herts., officially opened on June 29, where there are laboratory and pilot-plant facilities for process research and development over a wide field not limited to particular fields of technology. This article gives an idea of the Laboratory's scope and objectives.

A VISIT to the Warren Spring Laboratory leaves the impression that this establishment is setting itself up as a sort of 'Aunt Sally' for all sorts of chemical engineering problems which the research departments of universities and industrial firms cannot (or, in some cases, will not) tackle for themselves. Reflecting the D.S.I.R.'s new policy of taking sterner measures with the outstanding technical problems that are hindering the full development of industry in Britain, the Laboratory is genially resolved to condition its programme to industry's practical needs.

A good deal of the chemical engineering research being done at Stevenage seems to be inspired by the conclusions of the Cremer Committee and the subsequent investigations of the Association of British Chemical Manufacturers and the British Chemical Plant Manufacturers' Association into 'gaps' in chemical engineering knowledge. Thus the Laboratory's programme of work on distillation supplements that being carried out in the universities under the sponsorship of the A.B.C.M. and B.C.P.M.A. following the report of the Distillation Panel (summarised in our June issue). In addition to its main programme, the Laboratory undertakes to carry out certain research projects on behalf of industry, these being sponsored by the firms concerned.

The main target for the Laboratory's pilot-plant investigations at present is the improvement of mineral processing techniques and the synthesis of oil from carbon monoxide and hydrogen (Fischer-Tropsch). These are supported by basic research, including the research in chemical engineering which is being transferred from the National Chemical Laboratory.

The buildings

The Establishment, including buildings, services, fixed laboratory fittings, library bookshelves and all site works, was built at a total cost of some £620,000—equivalent to £6 7s./sq.ft. The main, three-storey building is 372 ft. long and 37 ft. 6 in. wide, the laboratories being housed within light, demountable partitioning for flexibility. A three-storey administration block runs at right-angles to the main building and there are three pilot-scale buildings linked to the main laboratory block by a corridor with small-scale laboratory units on each side.

Chemical engineering

The Chemical Engineering Division at Warren Spring, headed by Dr. P. H. Calderbank, has three functions:

(i) to carry out research on physical operations which play an important part both in processes which are under development in the Laboratory, and those in more general use in industry;

(ii) to undertake research in the field of chemical engineering sponsored by industry or by Government departments;

(iii) as a result of these functions to accumulate basic information in chemical engineering for use by other sections of the Laboratory and by industry.

As the D.S.I.R. is already carrying out work on heat transfer and fluid flow elsewhere, the Division is concentrating at present on problems of mass transfer, in particular to obtain data which will permit more accurate prediction of the performance of gas-liquid contacting equipment, and thus to facilitate the design of distillation columns, gas-absorption towers, and reactors of the liquid-phase type, of which the Fischer-Tropsch slurry reactor is a particular example. Four main lines of study are being followed:

Bubble dynamics. The evaluation of the gas-liquid interfacial area on distillation plates and its relation to the physical properties of the system and the operating variables of the equipment.

Gas-liquid mass transfer rates. Measurement and correlation of the liquid- and gas-phase mass transfer coefficients on distillation plates.

Fluid mixing. Evaluation of the degree of fluid mixing on distillation plates in such a form as to allow this factor to be introduced into the mass-transfer rate equations.

Specific problems in gas absorption with chemical reaction. The prediction of the overall rate in certain specific chemical reactions will involve the study of the reaction kinetics and associated physical rate processes.

Some pilot-scale experiments are at present being carried out in a laboratory originally designed for benches. One item of equipment here is a small distillation column fitted with a brass sieve plate and observation window allowing measurement of the reflectivity of the foam which forms in the column and providing a means of arriving at the interfacial area.

Work is also being carried out on promoters of dropwise condensation for heat exchangers, a study of the mode of action of such promoters being aimed to help in the development of compounds which will be effective for prolonged periods with a wide range of metal surfaces. It is proposed to study the mechanism of synthetic promoters to metal surfaces by labelling with a radiochemical substance (C_{14}) and to observe the subsequent history of these substances under conditions of use in heat exchangers.

Oils and chemicals from coal

As part of the Ministry of Works' programme to find ways of making more efficient use of fuel in Britain, the Laboratory is carrying on with the studies of the synthesis of oils and chemicals from carbon monoxide and hydrogen previously carried out at the Fuel Research Station at Greenwich (which the new Stevenage laboratory replaces). The original aim of this project was to help in the development of an economic process for producing oil from coal, but it can also be seen as an investigation involving development between the discovery of a

reaction of potential industrial importance and the design and building of full-scale commercial plant.

The development of oils from coal is a two-stage process involving (i) the complete gasification of the coal to yield a mixture of carbon monoxide and hydrogen, and (ii) the catalytic conversion of the gas mixture into the desired end-products. The work at Warren Spring is concerned only with stage (ii). Economic considerations indicate that the most promising version of the Fischer-Tropsch process for use under British conditions is the ' slurry ' process, in which the gas mixture is passed through a suspension of powdered catalyst in molten wax at 250 to 300°C. and at pressures between 5 and 30 atm.

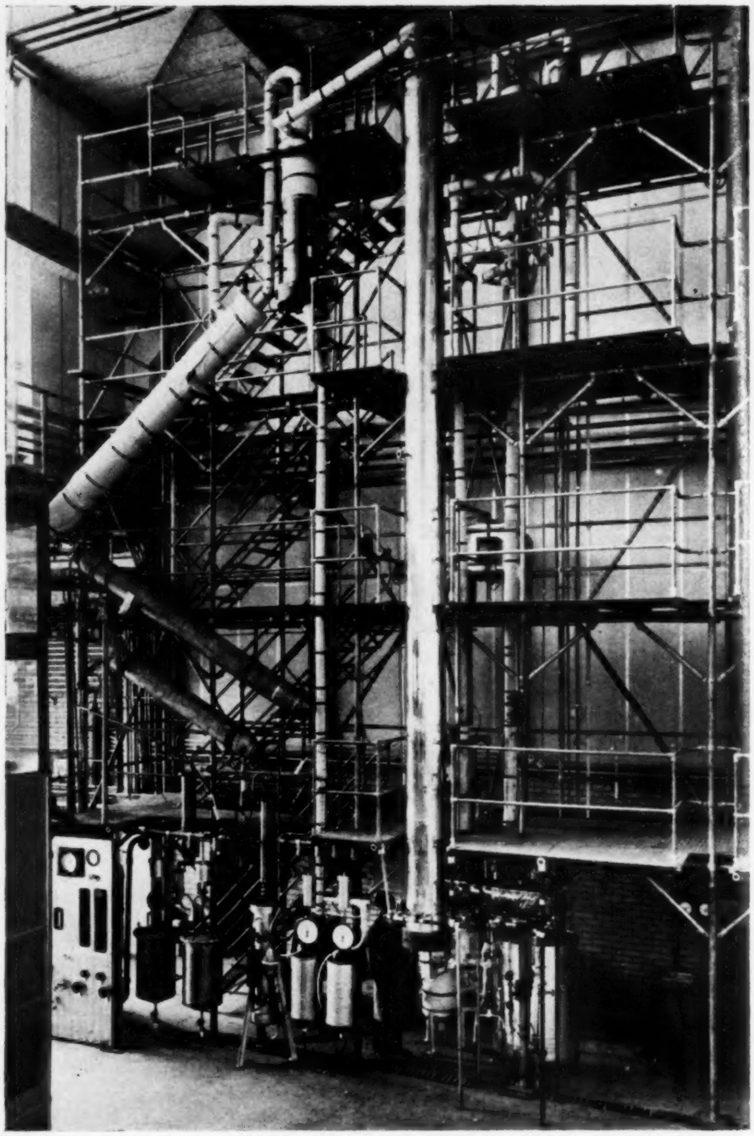
The objectives of the programme are:

(*a*) to develop an iron catalyst of longer life and higher activity than those at present available, and one that will yield a high proportion of desired end products;

(*b*) to select operating conditions (gas composition, temperature, pressure) to combine a high reaction-velocity with a given distribution of end-products;

(*c*) to obtain data necessary to design a full-scale reaction vessel.

Synthesis gas is produced on the site at a rate of 4,500 std. cu.ft./hr. in a standard, water-gas generator. There are arrangements for feeding carbon dioxide with the steam so as to vary the hydrogen/carbon monoxide ratio between 1.15 and 0.6. The gas is purified from hydrogen sulphide in *Gastechnik* towers and washed with caustic soda to control the carbon dioxide content. It is then compressed to 15 atm. pressure in the first two stages of a four-stage compressor, passed through the active carbon scrubbers to remove organic sulphur compounds, and then further compressed in the third and fourth stages to a pressure of 120 atm. The gas plant was designed and erected by Humphreys & Glasgow Ltd.



Fischer-Tropsch pilot plant at the Warren Spring Laboratory. The reactor column is 28 ft. long and 18 in. in diameter. The two containers behind the operator at the foot of the column are for soft and hard wax; the cylindrical vessel to the right of the column is the mixer.

In addition to the Fischer-Tropsch pilot plant there are six bench-scale units operated by the Process Development Division of the Laboratory for the testing of catalysts, treatment of catalysts, etc. The Fischer-Tropsch pilot plant takes up to about 3,000 cu.ft./hr. of synthesis gas.

Mineral processing

The mineral processing laboratories are equipped to handle most laboratory-scale mineral-dressing operations such as flotation, jigging, tabling, heavy-media separation, wet and dry magnetic separation, and high-voltage separation. In the hydrometallurgical field facilities are available for atmospheric and pressure leaching, for fluidised-bed roasting, chlorine metallurgy, and solvent extraction. Pilot-plant facilities enable primary crushing operations to be carried out on a scale up to 2½ tons/hr., and flotation plant is available for treating up to 1,000 lb./hr. It is possible to carry out full-scale tests with radioactive tracers.

It seems probable that for some time a fair proportion of the effort of the Division will be engaged on sponsored work on particular ores, but it is hoped that basic investigations will include:

(i) a study of grinding in the presence of additives such as surface-active agents;

(ii) the kinetics of bubble attachments to mineral surfaces, as a contribution to the knowledge in the field of froth flotation; and

(*Concluded on page* 258)

New Fertiliser Plants

Latest trends in fertiliser manufacture are exemplified by the new ammonium nitrate plant of Fisons, nitrogen fertiliser factory of Shell, and I.C.I. granular fertiliser factory.

AMMONIUM NITRATE

THE new ammonium nitrate factory of Fisons Ltd. at Stanford-le-Hope, Essex, is the outcome of the company's decision to produce for itself a more concentrated form of nitrogen than has been available in the ammonium sulphate hitherto used in its granular compound fertilisers. The plant has a capacity to produce 400 tons/day of NH_4NO_3.

Ammonia is pumped from the adjacent works of Shell Chemical Co. and stored in a 2,000-ton sphere. Part of it is oxidised to nitric acid, which is then neutralised with the remaining ammonia to make ammonium nitrate. The final product is an aqueous 86% solution which is transported hot to the compounding works in road and rail tankers.

Ammonium nitrate is produced by the Stengel process as developed by Commercial Solvents Corporation, New York. Nitric acid and ammonia are mixed in a 1-ft.-diam., stainless-steel reactor packed with Raschig rings, with a mixing device in the top section. Ammonium nitrate solution and steam from the base of the reactor flow through a separator, from which the product is pumped to storage *via* steam-traced lines.

The nitric acid plant has a capacity of 223 tons/day, the process used being a modification of the Du Pont process. Ammonia is catalytically oxidised by passing a 10% ammonia/air mixture through platinum-rhodium gauze pads.

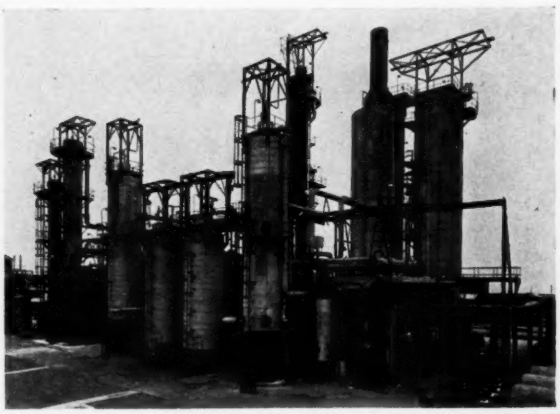
The recovery and re-use of waste heat is a notable feature of the Stanford plant, which is designed so that the energy released from burning ammonia is recoverable, and once the plant is started up no outside energy is needed for continuing production, except a minor amount of electricity to operate pumps. The compactness of both the ammonium nitrate and nitric acid plants is another striking feature, as is also the elimination of fumes from the nitric acid plant, using a special catalyst so as to yield a harmless, colourless effluent.

AMMONIA

AT Shell Haven, from which the new Fisons plant draws some of its raw materials, Shell Chemical Co. have opened new chemical fertiliser facilities which will produce 75,000 tons p.a. of ammonia for the U.K. agricultural market. Ammonia is made by combining nitrogen and hydrogen together in the presence of a catalyst. The nitrogen is obtained by liquefying air and then separating the liquid nitrogen and liquid oxygen by fractional distillation. The hydrogen is obtained by burning oil in a restricted amount of oxygen in the presence of steam, and adjusting the conditions so that the main products are hydrogen and carbon monoxide. More hydrogen is obtained by reacting steam with the carbon monoxide over a catalyst. The hydrogen is purified in a series of plants, mixed with the right amount of nitrogen, compressed and passed over another catalyst.

The ammonia so formed is kept under pressure, so that it remains liquid, and it is stored in a 1,000-ton sphere. Part of the ammonia is sold or used as such, the rest is burnt in air in the presence of a catalyst to give oxides of nitrogen, which are absorbed by water to give nitric acid. Some of the nitric acid is sold as such; the rest is neutralised with ammonia to give ammonium nitrate. This in turn is mixed with dry granular fertiliser.

Fisons' ammonium nitrate factory site showing the 2,000-ton sphere, and the 1-million and ½-million-gal. tanks for hot solutions.



During construction work on the new Shell chemical fertiliser plant, scale models were used and the photograph on the left shows a model of the air-separation plant. On the right is the synthesis-gas purification section during construction.

GRANULAR FERTILISER

I.C.I.'s 1,000 tons/day factory

TO I.C.I.'s Billingham complex of chemical plants, where nearly a million tons of fertiliser are produced each year, has been added a new granular fertiliser plant which is claimed to be the largest in Britain. The solid raw materials are imported muriate of potash and Billingham sulphate of ammonia, which are crushed, weighed and conveyed to a piece of equipment called a ' blunger.' Here they are mixed with monammonium phosphate liquor which is conveyed by road tankers from the Billingham phosphate reaction plant. Granulation begins in the ' blunger ' and is completed in a large rotary drier. From here the dried granules are screened, cooled and conveyed to an air-conditioned silo (capacity 100,000 tons) or to the packing shed.

For convenience of operation the plant is divided into two identical systems, the equipment being symmetrically arranged in the plant layout. Both systems are controlled from duplicate panels in the central control room. To protect the scrubbing boxes and associated ducting from corrosive vapours in the gases reaching them from the drier, extensive rubber lining was carried out. A special rubber compound was used to withstand traces of fluorine.

The concentrated complete fertiliser produced in this factory contains the three principal plant nutrients—nitrogen, phosphorus and potash—and was first produced at Billingham in 1930, shortly after the manufacture of monammonium phosphate was started there. Different compound fertilisers were added to the selling range and the plant was extended in 1933. During the war, when production reached record levels, the range of ' CCFs ' was limited in the interests of higher output and from 1946 only one was made. This contained 12% N, 12% P_2O_5, 15% K_2O, until in 1956 the potash content was increased to 18%.

Other operations at Billingham

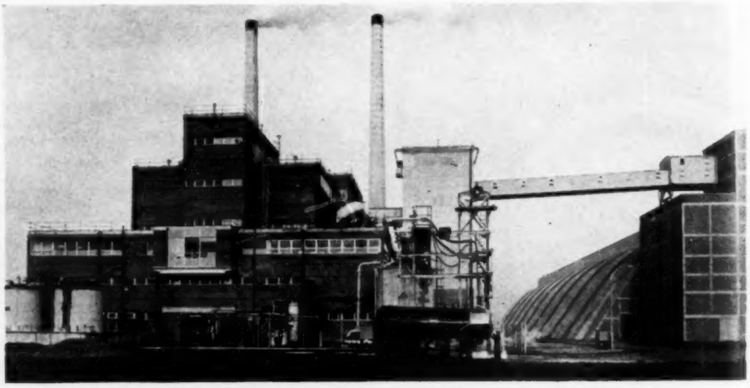
Since the early 1920's fertiliser manufacture has been one of the Billingham Division's principal activities and today fertilisers account for more than half the Division's total output. Apart from the new ' CCF ' factory there are plants for producing sulphate of ammonia (first produced at Billingham in 1923), *Nitro-Chalk* 55 (a granular fertiliser made from ammonium nitrate and chalk) and *Kaynitro* (a nitrogen-potash product) as well as urea.

A feature of the Billingham operations is that with only two exceptions —phosphate rock and potash, which are imported—all the principal raw materials are obtained from local resources. Another striking feature is the extent to which ' waste ' products, including clinker, boiler ash and gypsum, are utilised in the manufacture of other products. Some 90 different products are made, including fertilisers, acids, building products, organic chemicals, sodium, chlorine, cyanides, plastics and nylon polymer.

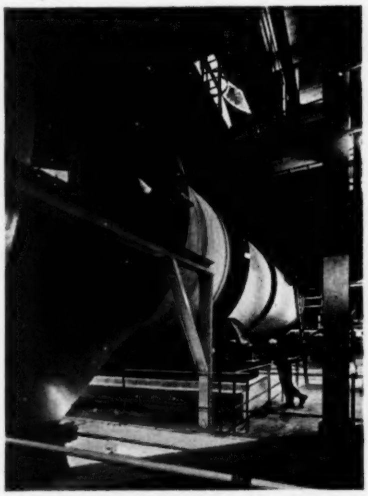
The key product at Billingham is ammonia, obtained by a high-pressure process based on the fixation of atmospheric nitrogen, and used as a raw material or intermediate in the production of several important industrial chemicals such as nitric acid and products derived from it, ammonium bicarbonate and urea. Some of the output of ammonia is sold direct to customers. Associated with the synthesis of ammonia are processes for the manufacture of methanol and liquid argon of exceptional purity, whilst carbon dioxide is produced in large quantities as a by-product.

Anhydrite mine

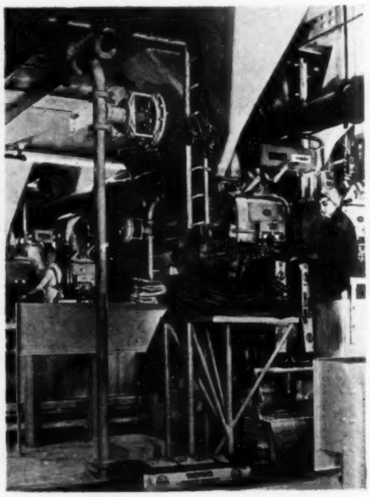
Anhydrite is one of the principal raw materials at Billingham, for instance in the manufacture of sulphuric acid and sulphate of ammonia, and the extensive mine beneath the site has been the subject of a modernisation scheme over the past 12 years, costing some £750,000. As a result, productivity has been increased and the mine now produces over 23,000 tons/week.



Exterior of CCF plant at Billingham, with storage silo on right.



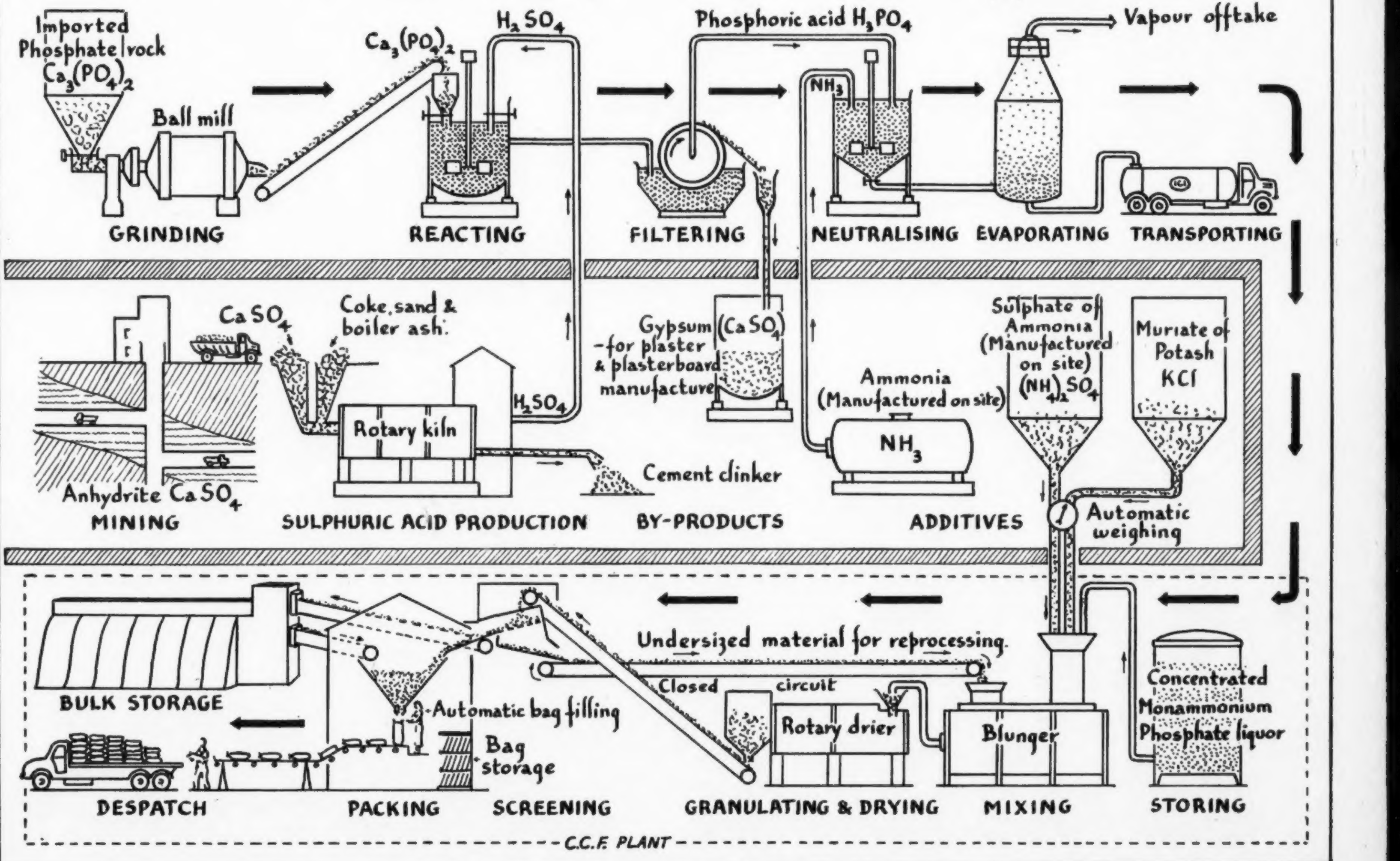
One of two rotary driers used in the granulation plant.



Filling CCF into paper bags. One girl looks after four filling points.

MANUFACTURE OF COMPLETE CONCENTRATED FERTILISER AT I.C.I., BILLINGHAM

With some associated processes for production of raw materials and by-products.



INDUSTRIAL PUBLICATIONS

Magnesium. The Magnesium Industry Council, 15 Took's Court, London, E.C.4, has prepared a 28-page illustrated booklet dealing with the properties and uses of magnesium and its alloys.

Chemical enterprise. A lavishly produced brochure from C. H. Bochringer Sohn, Ingelheim - am - Rhein, Germany, illustrates the activities of this old-established firm, including the production of fine chemicals, alkaloids, pharmaceuticals, agricultural chemicals, cosmetics, etc.

Pumps. A new folder includes illustrations of the various pump units manufactured by Girdlestone Pumps Ltd., including diaphragm, centrifugal, rotary and motor-driven pump units. Float switches are also illustrated and some typical industrial pumping installations are shown. Copies are available from the London sales office at 23 Davies Street, London, W.1.

Rubber hose. All kinds of hose—from the slender tubings of delicate instruments to suction hose of over 18 in. internal diam.—are included in the latest illustrated catalogue of BTR Industries Ltd., Herga House, Vincent Square, London, S.W.1. It gives useful information (including tabulated data) on practical features of design which have a bearing on the welfare and life of the hose.

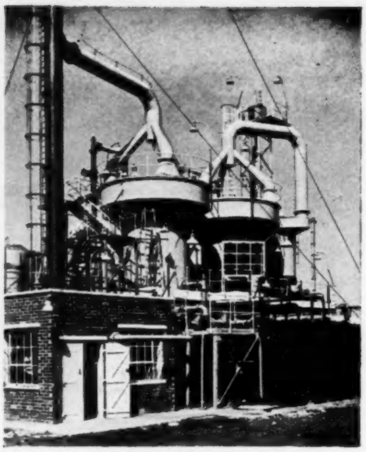
Surface-active agents. A new, illustrated booklet gives a full description of the general principles of non-ionic surface activity and the general properties and uses of *Nonex* non-ionic surface-active agents. The uses are grouped under various industries and typical formulations are also given. The booklet is available from Union Carbide Ltd., 103 Mount Street, London, W.1.

Rubber-reinforcing resins. A technical note on the use of *Cellobond* rubber-reinforcing resins in GR-S compounds has recently been published by British Resin Products Ltd., Devonshire House, Piccadilly, London, W.1. A comparison of GR-S rubber with natural rubber shows that GR-S has better resistance to ageing and heat but less tack, lower resilience and very low gum strength. It is claimed that the use of *Cellobond* resins will overcome these difficulties.

Metals for the atomic age. An illustrated booklet published by I.C.I. Metals Division, Imperial Chemical House, Millbank, London, S.W.1, details the part played by the division, including the I.C.I. subsidiary, Marston Excelsior Ltd., in the early days of nuclear engineering and the intensive research and development work which it has subsequently carried out in this field, both as regards new forms of traditional materials and fabrications and in the realm of the nuclear metals.

Glycerine data. A new data sheet gives a useful summary of the physical properties of glycerine including short tables showing specific gravity, freezing points and vapour pressure/relative humidity data for different concentrations of glycerine in water. The data sheet also describes the three principal grades of refined glycerine, namely chemically pure, technical grade and dynamite grade. The brochure is available on request to the Secretary, The United Kingdom Glycerine Producers Association Ltd., 5 Bridewell Place, London, E.C.4.

Silicone rubber. The latest publication issued by Midland Silicones Ltd., 68 Knightsbridge, London, S.W.1, gives some idea of the variety of uses to which silicone rubber is now being put in many types of industry. An interesting specialised application referred to is the specification by designers of atomic energy power stations of *Silastomer* silicone rubber for resilient seals on carbon dioxide-based heat-transfer systems. Further sections of the booklet deal with the resistance of *Silastomer* to extremes of temperature, chemical inertness and electrical insulating properties.



SULPHURIC ACID

This new sulphuric acid plant has recently been commissioned at the Eaglescliffe works of the Associated Chemical Companies Group. The contract was placed with the Power-Gas Corporation Ltd. who erect contact sulphuric acid plant to the design of Chemibau, Dr. A. Zieren GmbH., of Cologne. Tests have shown that the overall efficiency of the Eaglescliffe plant is very high. The rated capacity is 100 tons/day, but the plant is capable of working at an overload if required. Production acid can be delivered at various strengths up to 98.6%.

Pyrites prospects

In recent years furnaces have been developed to raise steam from the waste heat produced by the roasting of pyrites. The earlier types of these furnaces, while efficient, are only suitable for certain classes of pyrites. New furnaces suitable for the type of pyrites generally produced are being designed. The generation of steam as a by-product of the roasting process will give pyrites an additional advantage.

This point was made by Mr. W. P. Rutherford, chairman of the Tharsis Sulphur & Copper Co., at the company's annual general meeting. Referring to the competition between pyrites and sulphur as basic materials in the manufacture of sulphuric acid, he emphasised the 'composite' value of pyrites, arising from the fact that, whereas when sulphur is burnt for sulphuric acid manufacture it is wholly converted to gas, with pyrites 70% of the original weight remains as a residue containing iron and non-ferrous metals.

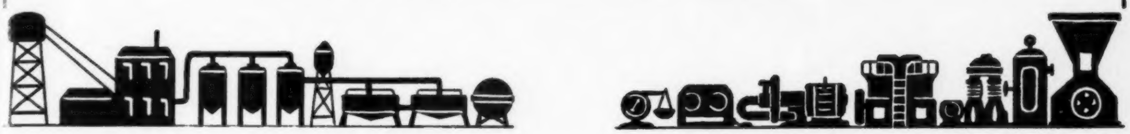
The company, like many other pyrites producers, experienced a reduced market for pyrites in the face of increased sulphur production, as in the production of Frasch sulphur in Mexico and from the sour-gas development of the Lacq field in France.

To Authors of Technical Articles and Books

The Editor welcomes practical articles and notes on chemical engineering and related subjects with a view to publication. A preliminary synopsis outlining the subject should be sent to The Editor, CHEMICAL & PROCESS ENGINEERING, Leonard Hill House, Eden Street, London, N.W.1.

In addition, the Publishers and Editors of the Leonard Hill Technical Group are always ready to consider technical and scientific manuscripts with a view to publication. Correspondence should be addressed in the first instance to the Book Production Manager, at the above address.

WHAT'S NEW



Plant • Equipment • Materials • Processes

CPE reference numbers are appended to all items appearing in these pages to make it easy for readers to obtain quickly, and free of charge, full details of any equipment, machinery, materials, processes, etc., in which they are interested. Simply fill in the top postcard attached, giving the appropriate reference number(s), and post it.

Vacuum insulates liquid gas

Special mobile pumping units for the vacuum insulation of liquid argon containers have been produced by Edwards High Vacuum Ltd., in conjunction with I.C.I. engineers, for the Billingham Division.

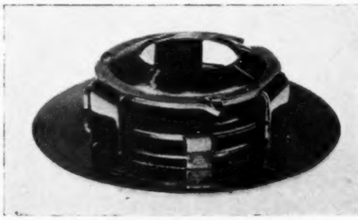
Each unit has a framework of tubular steel approximately 42 in. high. The metal base on which the rotary pump is mounted is fitted with castors and screw jacks. The two-stage, air-ballasted rotary pump is capable of attaining an ultimate vacuum of 0.0001 torr and has a displacement of 144 l./min. **CPE 1280**

High efficiency, low cost claimed for new distillation trays

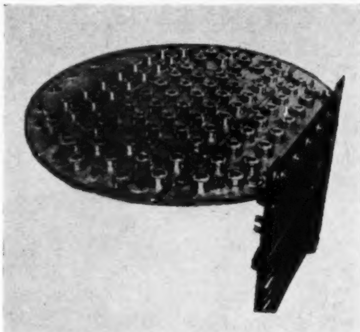
The new *Glitsch* ballast tray which is offered by Metal Propellers Ltd. can roughly be described as a bubble-cap tray in which the cap and riser assembly is replaced by a unit producing constant vapour velocity through a variable annular slot. It can also be classed as a sieve tray with apertures which are sealed at zero vapour rates; indeed, it is claimed to incorporate the virtues of both bubble-cap and sieve trays, avoiding their weaknesses, and to offer considerable economic advantages.

Throughout the range of operations, the size of vapour opening maintains optimum slot vapour velocity required for maximum tray efficiency. At the same time vertical vapour velocities at high flow rates are kept down and the essentially deck-level horizontal vapour flow ensures minimum entrainment. The simple vapour flow path produces minimum parasitic pressure drop and facilitates the design of trays for vacuum operation.

Turndown ratio of 9 to 1 or better is obtainable, high efficiency over a very wide range of capacity being achieved by reason of the compact ballast unit (2 in. diam. × $\frac{3}{4}$ in. high).



The new 'Glitsch' ballast unit . . .



. . . and a complete ballast tray.

Violent turbulence in the area of the ballast unit makes it virtually self-cleaning in dirty service. There are no dead areas on the tray where deposits can build up. There is only point contact between the components of the unit and sticking does not occur.

The tray embodies standard *Glitsch* structural features and can use existing tower rings and downcomers so that replacements to obtain increased tower capacity are a simple and straightforward proposition. **CPE 1281**

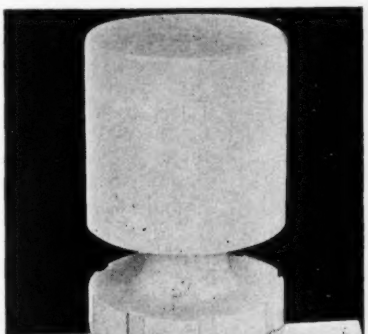
Solenoid valve

An electric solenoid valve for the control of corrosive fluids, introduced by Ether Ltd., is so designed that the fluid only comes into contact with a plastic material (nylon or high-density polythene) and synthetic rubber. It incorporates a $\frac{3}{8}$-in.-diam. orifice and is pilot-operated. The valve can be made suitable for any electrical supply and is capable of controlling fluids passing at pressures up to 40 p.s.i. **CPE 1282**

Two new gate valves

Two gate valves, for pressures up to 100 and 250 p.s.i., have been added to the range of Robert Cort & Son Ltd. Both have cast-iron bodies and seat rings, carbon-steel, hard-chrome-plated gates, and can be trimmed to suit the particular application. Rubber 'O' rings are employed between the body and the floating seats and between the seats and the slide gate and the bearing housing to cover joint also is sealed by 'O' rings. The valves are reversible in line and seal on both sides of the gate under all pressure conditions.

The Cort 100 is a through-conduit venturi valve with non-rising spindle so as to obtain minimum overall dimensions. The use of the venturi combined with through conduit gives a pressure loss across the valve no greater than that of a full-ported plug valve and less than that of a parallel



Solenoid valve for corrosives.

bore sluice valve. The working parts are isolated from the line flow in both the open and closed settings and thus corrosion, erosion and sedimentation in the body cavity are at a minimum.

The Cort 250 is a parallel-bore, through-conduit valve with rising spindle and protective cover with all the other features of the Cort 100. Both valves have been designed to permit easy fitting of electric, hydraulic and pneumatic actuators and are available with or without indicators. They are claimed to be ideally suited for handling gases, water and chemicals up to the maximum working temperature of their rubber seals. **CPE 1283**

Metering pumps

High accuracy is claimed for a new series of directly controlled metering pumps for general chemical applications. Capacities range from 0 to $1\frac{1}{2}$ up to 180 gal./hr.

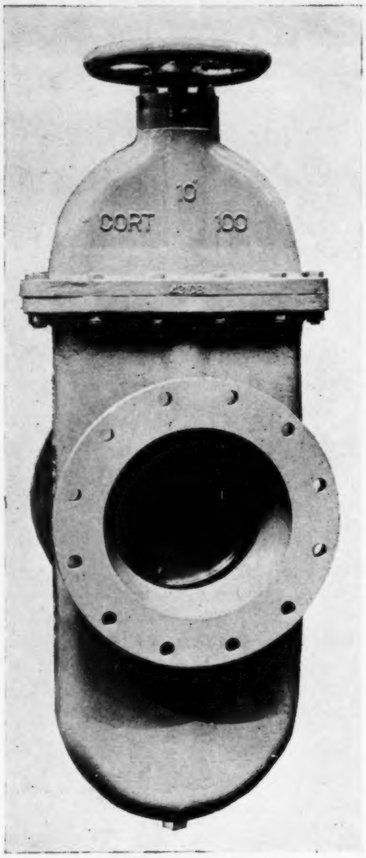
The pump consists of a hermetically sealed, controlled-displacement diaphragm pump (the metering head) together with a motorised reciprocating oil pump (the actuating pump), the function of which is to provide a remote hydraulic drive to the metering head.

The manufacturers, Kontak Manufacturing Co. Ltd., claim an accuracy of less than $\pm 2\%$ within specified conditions and $\pm \frac{1}{2}\%$ on repeatability under fixed conditions. Among other advantages claimed for the remote-actuated pump are its ability to handle abrasive slurries and to run 'stalled' indefinitely without damage when operating against a blocked system.
CPE 1284

Vibratory debunkering

Discharge from storage bunkers containing powdered, granulated, or lump materials that tend to arch, pack or funnel, can be ensured by a new internal bunker vibrator, made by Sinex Engineering Co. Ltd. The equipment overcomes the problem of discharging large concrete bunkers where external vibrators cannot be applied and in other applications can be combined with external vibrators for dealing with very difficult materials.

The device consists of a rotary electric vibrator attached to a mild-steel reed which hangs down into the bunker. The assembly is suspended from a rolled-steel joist across the top of the bunker by anti-vibration mountings. The vibration passes down the reed with increasing amplitude, reaching a maximum at the lower end where the material has a tendency to



Cort 100-p.s.i. gate valve.

arch. As vibration loosens and releases the material, the pressure on the reed varies and causes it to bend and move about; vibration is therefore always applied at the most needed point.

The dimensions of the reed vary between 18 and 24 in. wide, $\frac{1}{8}$ to $\frac{3}{8}$ in. thick and up to 60 ft. in length. **CPE 1285**

Smog gets bogged in this air filter panel

The *Super-Vee* throw-away-type air filter panel, from Vokes Ltd., is claimed to be the answer for air filtration in areas where heavy smog conditions prevail or where atmospheric contamination is generally at a high level.

It has a unique synthetic fibrous medium, impregnated with an improved adhesive, and is ideal for the collection of sooty or tarry deposits without the danger of fibre migration. However it will not deal with objectionable fumes or gases, usually present during smog conditions. The medium is unaffected by moisture, will not crack, and can be supplied in flame-resistant form. **CPE 1286**

Instrument technology with the lid off

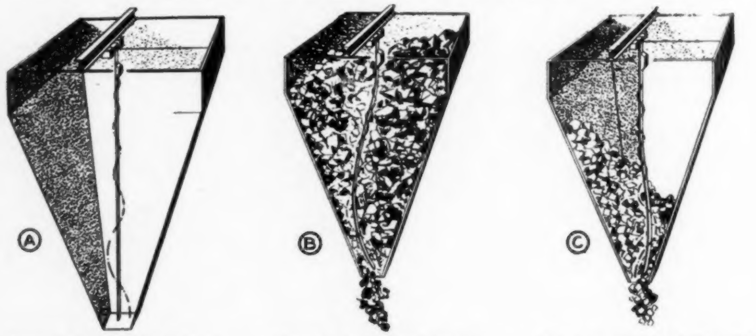
Visual aids to technical training are now available to industrial and educational training establishments in a form which enables the operational functions and details of construction and maintenance to be studied. The instrument mechanisms are exactly similar to those supplied for industrial applications, but are provided with transparent windows and other facilities.

The three main types of units available from Evershed & Vignoles Ltd. are:

(*a*) A model servo mechanism designed to demonstrate the actions and arrangements of a number of diverse servo mechanisms.

(*b*) A process controller and simulator of standard type used in many of the process industries.

(*c*) *Megger* testing sets mounted under transparent covers and shown



Shows schematically the vibration impulses travelling down the reed.

Shows the beginning of discharge causing differences in pressure of material on the reed which bends, thus moving the tip to a different position.

Shows a partially discharged bunker with the bulk of the material on one side bending the reed so that the vibrating tip bends towards a point beneath that bulk, thus ensuring efficient discharge.

How the bunker vibrator works: vibrations travel down from the electrical unit.

'expanded.' Insulation, continuity and earth testing procedures can be demonstrated on all but one of these instruments. **CPE 1287**

Provides an uplift in hazardous areas

Chain pulley blocks are available with flameproof electrical equipment and lifting capacities of from 5 cwt. to 10 tons. With the exception of hook suspension, blocks may be arranged for normal suspension mountings, including hand-pushed, hand-geared and powered traverse trolleys.

In most applications electric current can be supplied through festooned armoured cables suspended from a catenary wire or from supporting trolleys running on a light door track. Alternatively reeling drums are available, while in certain cases trailing armoured cable with flameproof plugs and sockets can be used. Makers: Geo. W. King Ltd. **CPE 1288**

Dry air comes cool, clean and quickly

An uninterrupted flow of air to zero humidity and clean to 0.5 micron can be supplied by the *Pathfinder* air pump cabinet. It is fully portable and can operate continually all year round. In its standard form it supplies 10 cu.ft./min. of air at up to 60 p.s.i.g. or 10 cu.ft./min. at 15 p.s.i.g. at any required humidity between zero and ambient. It occupies a floor area of less than 3 ft. square, is under 6 ft. in height, and fitted with castors.

The air is supplied by two horizontal two-stage compressors of the oil-free carbon-ring type or a fully rotary-type compressor. To obtain maximum pre-cooling, the output of a fan mounted on the end of the motor shaft is directed by a two-way ducting to the compressor heads in the case of the 60 p.s.i.g. compressors. The unit is available from B.M.B. (Sales) Ltd. **CPE 1289**

Glandless and leakless pump.

Leakless pumping

For pumping liquids without leakage whatsoever, Sigmund Pumps Ltd. are offering a new, compact unit in stainless steel. The pump is of the canned-rotor type, completely eliminating glands and mechanical seals. The bearings are lubricated entirely by the pumped liquid.

The rotating element, mounted on a fixed stationary axle, is hydraulically and dynamically balanced for smooth operation; it can be withdrawn without breaking the pipeline joints and without interference with the electrical connections.

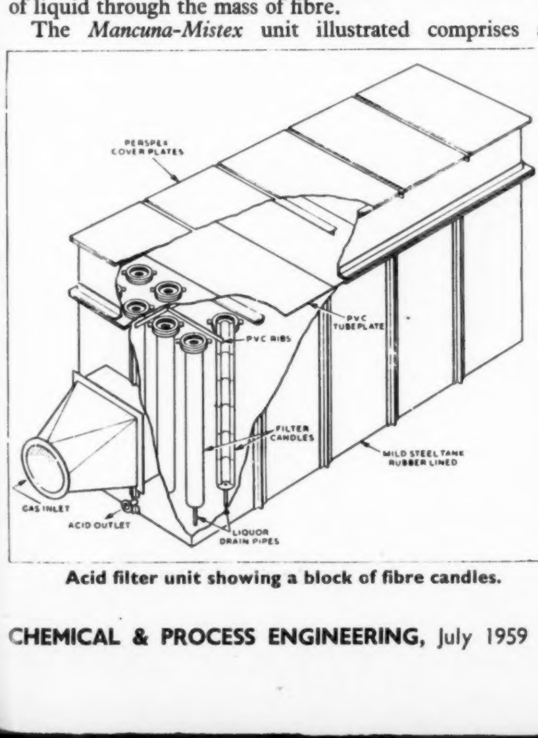
The totally-enclosed stator is suitable, in the standard design, for pumping liquids at temperatures up to 260°F. and, with special windings, from sub-zero to 400°F. **CPE 1290**

Fibre filters mists and fumes

A new fibre filter which virtually eliminates the emission of very fine acid mist particles from the tail gases of major acid-producing plant is to be made commercially available in the U.K. Other applications besides sulphuric acid manufacture are envisaged.

High-efficiency filtration is achieved using fine-diameter hydrophobic fibres, resulting in the impingement of very fine liquid particles and a very free dispersion and drainage of liquid through the mass of fibre.

The *Mancuna-Mistex* unit illustrated comprises an assembly of blocks of standard filter candles each consisting of six 10-in.-long elements sealed together to form one composite candle. Including the steel tank and top outlet chamber, the unit will stand approximately 6 ft. high though some 13 ft. of headroom will be necessary to permit the withdrawal of candles.



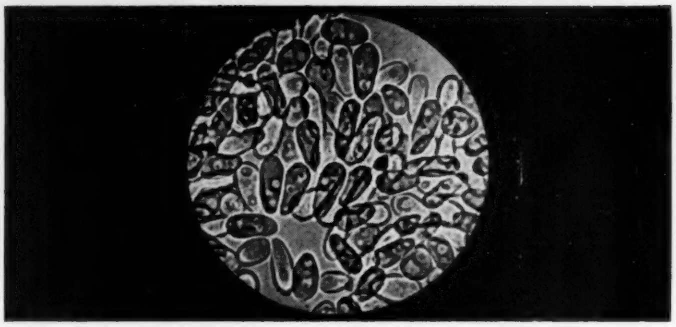
Acid filter unit showing a block of fibre candles.

It is intended that units should be introduced into existing plant through ducts incorporating 'U' bends which can be used as individual water seals. The liquid removed from the gas discharges down the centre core of the candle and is removed from the tank through a simple acid outlet. Should there be any breakdown in one or other of the candles, mist channelling through the filter pad into the centre core of the candle will be clearly visible through the perspex cover plates. The unit can be isolated by flooding with water.

It is anticipated that one candle of six elements with a 10-in. w.g. pressure drop will handle some 200 cu.ft./min. of air. Where the acid mist comprises droplets which are 100% below two microns the performance has been such that an inlet concentration of 0.1 g. H_2SO_4/cu.m. has been reduced to an emission to atmosphere of a mist concentration of 0.0005 to 0.0007 g. H_2SO_4/cu.m.

The emission of mists does not increase where there is a fluctuating increase in the inlet concentration. The packing density required in the pre-forming of the glass fibre or *Terylene* filter elements can be determined by isokinetic sampling methods.

The new filter resulted from research work within the General Chemicals Division of I.C.I. Mancuna Engineering Ltd. have been granted a manufacturing and selling licence and are engaged in the detailed design of standard units and components. In addition to the *Mancuna-Mistex* unit an irrigated form of the filter will be offered under the name of *Mancuna-Fumex*. **CPE 1291**



Photomicrograph by the Distillers Company Limited

K_F = *filtration constant*

Results are scientific if they can be reproduced.

The FORD system of grading filtration media removes one variable from your calculations. Each time you employ a specific grade of sterilising, deodorising, decolorising, depyrogenating, or ordinary filtration material from FORD's, you can be sure that its performance will be exactly the same as any previous batch of FORD material of the same grade. Please write, stating your occupational interest. You will receive literature and samples that explain the FORD system of grading filtration media, and the rigid standards imposed during manufacture.

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CHEMICAL & PROCESS ENGINEERING NOMOGRAM

Linear Velocity of Air in Ducts

By D. S. Davis

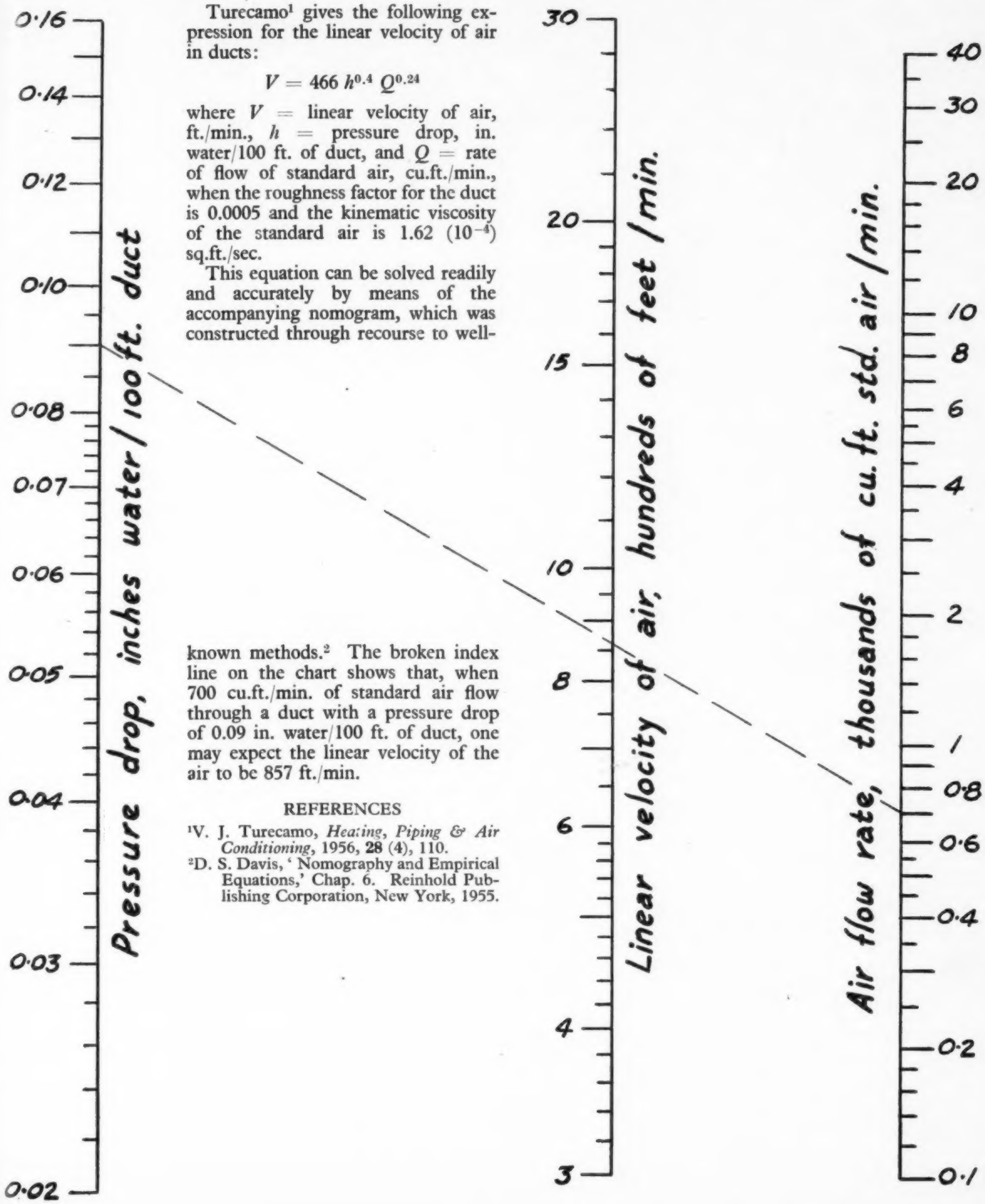
(Head, Department of Pulp and Paper Technology, University of Alabama)

Turecamo[1] gives the following expression for the linear velocity of air in ducts:

$$V = 466\ h^{0.4}\ Q^{0.24}$$

where V = linear velocity of air, ft./min., h = pressure drop, in. water/100 ft. of duct, and Q = rate of flow of standard air, cu.ft./min., when the roughness factor for the duct is 0.0005 and the kinematic viscosity of the standard air is 1.62 (10^{-4}) sq.ft./sec.

This equation can be solved readily and accurately by means of the accompanying nomogram, which was constructed through recourse to well-known methods.[2] The broken index line on the chart shows that, when 700 cu.ft./min. of standard air flow through a duct with a pressure drop of 0.09 in. water/100 ft. of duct, one may expect the linear velocity of the air to be 857 ft./min.



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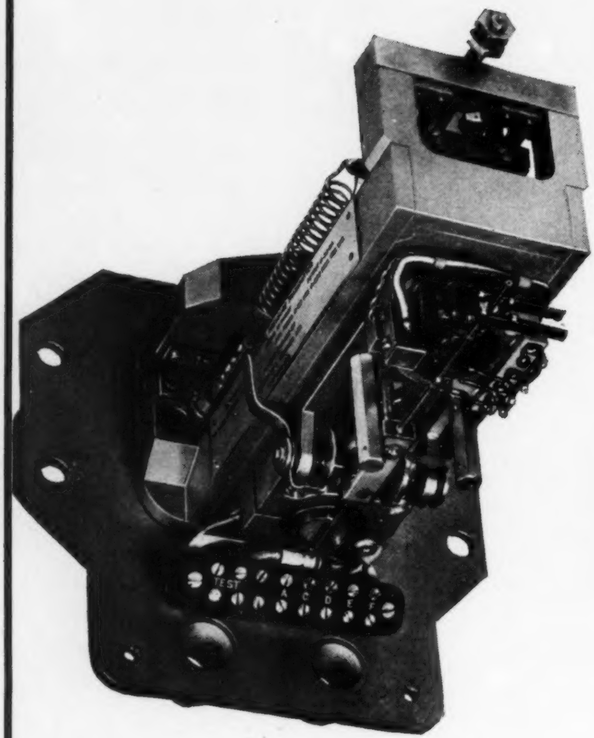
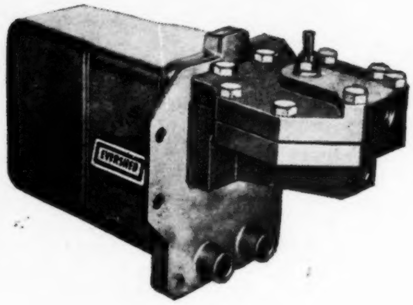
[1] V. J. Turecamo, *Heating, Piping & Air Conditioning*, 1956, **28** (4), 110.

[2] D. S. Davis, ' Nomography and Empirical Equations,' Chap. 6. Reinhold Publishing Corporation, New York, 1955.





World News

UNITED STATES

$6-million chlorine project

Latest-type electrolytic cells for the production of chlorine and caustic soda are involved in plans for an investment of more than $6 million in the Niagara Falls chemical facilities of Olin Mathieson Chemical Corporation.

The new cells will occupy less space and make possible an increase in chlorine tonnage, while it will be possible at some future date to expand the line of speciality products now produced in the industrial chemicals plant. These at present include high-test hypochlorite, sodium methylate and sodium chlorite.

Niagara Falls was the scene of much of the electro-chemical research that led to the development of the new Mathieson electrolytic cells now installed in the corporation's McIntosh, Ala., and Saltville, Va., plants. The original industrial chemical plant on Buffalo Avenue was built in 1896, and some of the mercury cells began production the next year. The present plant contains more than 2,000 cells.

INDIA

British 'know-how' for dyestuffs plant

The new dyestuffs plant of Hickson & Dadajee Private Ltd. was recently opened on the outskirts of Bombay. Initially it is manufacturing sulphur black and *Photine* optical whitening agents, but a licence has been obtained from the Indian Government for the manufacture of 21 intermediates for dyestuffs, paints and pharmaceuticals.

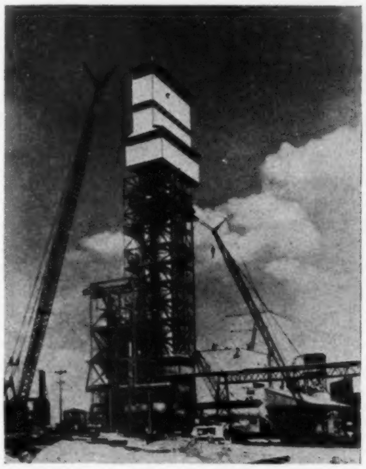
Hickson & Dadajee Private Ltd. was incorporated in 1953 by Hickson & Welch Ltd., England, and Dadajee Dhackjee & Co. Private Ltd., Bombay. In June 1954 a temporary plant was erected in a leased factory at Sewree; it commenced the manufacture of sulphur black one year later. In 1957 the Indian Government sanctioned a rise in production from 450 to 900 tons p.a. and also gave a licence for the manufacture of optical whitening agents and intermediates. To meet this demand the new site was purchased and construction commenced in May 1958.

GHANA

New industrial undertakings

Industrial undertakings which have recently been started or planned include: the manufacture of insecticides (I.C.I.-Tema), soap (U.A.C.-Tema), aluminium fabrications (Aluminium Union-Tema), cement (Tunnel-Takoradi), distilling (I.D.C.-Trans-Volta Togoland).

In addition Israeli interests have been reported to be investigating the manufacture of pharmaceuticals and salt; Liberian interests were to establish a distillery in T.V.T. and local and United Kingdom interests were considering a sugar refinery near Ho.



This 100 tons/day urea plant of Monsanto Chemical Co. at El Dorado, U.S.A., is one of two brought on stream recently by Chemical Construction (G.B.) Ltd., the other being a 200 tons/day plant for Cyanamid of Canada at Hamilton, Canada. Both plants are reported to be running well.

PAKISTAN

Oil-refining project

The Pakistan Government have had discussions with a French oil expert (Mr. R. Navarre, chairman of the Petroleum Institute of France) and a team of oil technicians for the establishment of an oil refinery in Karachi with an annual throughput of 1.5 million tons of crude oil.

HUNGARY

Chemical industry accident rate drops

Despite a 20% increase in the number of workers, accidents in the Hungarian chemical industry dropped by 10% last year.

Working conditions in the industry have been considerably improved, the Minister of Heavy Industry told a recent conference on industrial safety. More than £1,100,000 was spent by the Ministry last year on safety installations and protective clothing and £360,000 went to provide protective food and drinks for workers in the industry.

GREAT BRITAIN

Gas-oil desulphuriser

Under construction at Shell Haven refinery in the Thames estuary, at a cost of more than £2 million, is a *Hydrodesulphuriser* for the removal of sulphur from petroleum products by the Shell 'trickle-phase' technique.

In this operation, gas oil to be desulphurised is contacted with hydrogen and made to trickle over a special catalyst. The hydrogen, which will be drawn from the *Platformer* unit at Shell Haven, converts the sulphur compounds into hydrogen sulphide which will be processed to make some 20 tons/day of pure liquid sulphur.

HOLLAND

Sulphuric acid plant

A new company to be called Albatros Sulphuric Acid Chemical Works will be formed by the Albatros Superphosphate Works of Utrecht and the Cyprus Mines Corporation of Los Angeles on a joint basis. The company will operate a sulphuric acid plant which is to be built at Pernis, near Rotterdam, and which will have a capacity of 120,000 tons of concentrated sulphuric acid.

U.S.S.R.

Chemicals from shale

A very large chemical plant, to be built in Estonia, will get its raw materials from the local shale deposits, estimated at many thousands of millions of tons. The plant, which will produce nitrogenous fertilisers and chemical raw materials for the north-west of the U.S.S.R., will become the basis for the production of synthetic rubber, artificial fibres and other products.

A new technique will be used in the chemical treatment of shale. With the present equipment, refining takes a number of hours, whereas by using the new technique it will be done in practically the same number of minutes. Moreover, this process makes it possible to carry out a drastic reduction in the overall dimensions of the equipment.

Synthetic rubber

A plant producing synthetic rubber —the first of its kind in Kazakhstan— will go into operation this year in

Temir Tau, near the Karaganda metallurgical works. The plant will process the gases and liquid products of the coking department of the metallurgical works, the products of oil refineries and, later on, combustible gases from the Urals-Embinsk basin.

Some sections of the plant, which are already in operation, are producing calcium carbide, acetic acid and other chemicals in large quantities.

BELGIUM

Cellulose and wood pulp

The Canadian company Parsons & Whittemore has concluded an agreement with Sebelpa (a Belgian company studying the possible use of wood waste from the Ardennes forests) for the creation of a cellulose and wood pulp industry at Recogne in the Luxembourg Province. An investment of B. Frs. 400 million has been mentioned. The plant will have a capacity of 100 tons/day of bleached pulp to be processed into bleached kraft pulp and cellulose. It is believed that the Belgian personnel will be trained at their recently constructed plant at Saint Gaudens in Aquitaine (France). The Belgian company operating the plant will be known as Société Industrielle du Bois et de la Cellulose des Ardennes.

CHINA

Chemical works

The first stage of the Foochow No. 2 chemical works has been completed. Products will include caustic soda (15,000 tons p.a.), PVC (6,000 tons), insecticide (6,000 tons), chloroprene (6,000), calcium carbide and chloride. Two indanthrene workshops have gone into operation in the Kirin dyestuffs plant. A synthetic ammonia fertiliser plant has been completed, with Soviet assistance, in the Lanchow chemical works.

£ s d

CHEMICAL PLANT COSTS

Cost indices for the month of May 1959 are as follows:

Plant Construction Index: 180.0

Equipment Cost Index: 165.2

(June 1949 = 100)

£ s d

Personal Paragraphs

★ **Mr. H. Curtis,** a director of Leda Chemicals Ltd. (a subsidiary of F. W. Berk & Co. Ltd.), died recently at the age of 39. He was responsible for production and chemical engineering.

★ **Mr. J. Frisken** has been elected president of the Fertiliser Society and **Dr. H. L. Richardson** vice-president. **Dr. G. W. Cooke, Mr. H. B. Hill** and **Mr. H. C. Kidd** were elected to fill vacancies on the council.

★ **Mr. H. G. W. Chichester-Miles,** chairman of the Empire Rubber Co. and of Rubber Bonders Ltd., has been elected president of the Federation of British Rubber and Allied Manufacturers for 1959-60. Vice-presidents for the same term are **Mr. S. D. Sutton** of Veedip Ltd. and **Mr. C. H. M. Baker** of the Firestone Tyre & Rubber Co. Ltd.

★ **Mr. C. F. Bonnet** has been appointed associate director for the European Region of Cyanamid International at the company's European headquarters in Zurich. He has been associated with Cyanamid for 25 years.

The 'Odd-job Boys' of Process Development

(*Concluded from page* 246)

(iii) a study of the behaviour of mineral particles in a high tension field, and the modification of this behaviour by various surface treatments.

Many of the problems on which work is likely to be necessary concern overseas deposits. Already a number of requests for investigations have been received from overseas territories, and an Overseas Mineral Processing Advisory Committee has been set up to advise on the selection and priorities of the programmes of interest to these territories.

Towards cleaner air

In addition to its mineral-processing and process-and-development work the Laboratory will carry on the research on atmospheric pollution begun at Greenwich. One interesting line of research there was concerned with the removal of sulphur from flue gases. The Fuel Research Station at Greenwich investigated proposals to scrub flue gases with ammonia solutions and recover the sulphur as ammonium sulphate and found the process practically and economically feasible. The Central Electricity Generating Board and Simon-Carves Ltd. completed demonstration work on a large unit and confirmed the favourable cost estimates. Supplies of ammonia and the demand for ammonium sulphate limit the application of this process. Other proposals have therefore been investigated; for instance, involving the recovery of sulphur as sulphuric acid.

Pipe cleaning at a tar works

Striking economies have been effected in cleaning pipes and tubes of the convection-type tar heater, heat exchangers and condenser at the Preston distillation plant of Lancashire Tar Distillers Ltd., which has recently been thoroughly cleaned after distilling more than 112,000 tons of crude coal tar.

The system makes extensive use of the unwanted heat of the various products, and the incoming tar is heated four times in various heat exchangers before being sent through the convection furnace. When operating at full efficiency, with a capacity of 250 tons/day, the total pressure in the tar system is of the order of 40 to 60 p.s.i. However, as deposits accumulate in the various lines and heat exchangers this pressure increases and may reach as high as 90 p.s.i., when cleaning becomes necessary.

The deposit normally consists of a dense, gummy tar residue, which becomes extremely hard when overheated and carbonised. It usually builds up in irregular and uneven shapes along the inner walls of pipes and tubes and is rarely of even thickness. Its removal from the various sizes of pipes, bends and tube work of the heaters and heat exchangers was effected by using *Lagonda* tube cleaning equipment supplied by the Consolidated Pneumatic Tool Co. Ltd.—a range of three types of pneumatically operated motors coupled to a variety of types of cutter head being used.

Control in relays

Five different types of constant-differential relay made by Sunvic Controls Ltd., Harlow, Essex, are now available with built-in variable area flow meter (*Rotameter*) and needle valve. These relays can be used to ensure a constant bubbling rate of purging air or gas in air reaction systems for liquid-level measurement. No liquid whatsoever is used in the purge flow controller and so no maintenance is required.

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